How can PhD supervisors help foster independent and critical student work in a multicultural setting?

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Preface

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This is the 12th volume of the Department of Science Education's series of anthologies based on participant's development projects made in relation to the Teaching and Learning in Higher Education programme ("Univeristetspædgogikum" or UP) at the University of Copenhagen. The series is published in both hard copy, print-on-demand at lulu.com as well as digital versions, which can be downloaded from the webpage of the Department of Science Education under publications. It is possible to search through previous projects in the anthology by using the local search engine found here: http://www.ind.ku.dk/publikationer/up_projekter/.

This volume consists mainly of project reports written by participants from the January 2017 course. Each participant is required to conduct a small-scale development project as part of UP. The projects show how individual teachers have identified specific problems relating directly to their teaching practices and includes their reflections on how to develop their practice and the quality of teaching more generally.

Topics covered in the projects include course design and redesign, constructive alignment, research based teaching, feedback to name a few. This anthology is organized into parts based on some of the recurring overarching topics to give the reader a structured overview.

We would like to thank all the authors for their valuable contributions to the promotion of Scholarship of Teaching and Learning at the University of Copenhagen.

Part I

Student motivation

1

Motivation and course selection: a student's view

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Introduction

This assessment aims to gain insight into the thoughts and motivation that are involved when university students select their optional courses - for example at M.Sc. level. Being able to design a course that match the expectations of the students has a number of considerable benefits both to the students, to the academic course coordinator, and to the host institute. First of all, the course content and design, including the wording in the course description, must appeal to the students in order to attrack their attention and ultimately make them sign up for the course. However, if the student's underlying motiviation and educational focus is essentially unknown, it is potentially very difficult to design a course that will attract a sufficient number of students and the course may therefore easily fail already at the initial sign-up stage. For example, it is important to know if you can expect that the students, you are targeting for a given course, are motivated out of pure interest and passion for the topic(s) in question, or if they are specifically selecting courses that they think are more likely to directly benefit their career. For obvious reasons, these are not mutually exclusive points but there might still be a tendency that students within some academic disciplines will speculate more directly in career advancing strategies than in others, and it is a major advantage for the course coordinator to know his/her audience in that regard.

Secondly, understanding the student's underlying motivation will make it much easier to design and carry out a course that can meet (or challenge, where appropriate) their expectations. These insights will for example make it possible to perform a Constructive Alignment analysis (Biggs, 2011; Mørcke & Rump, 2015) where the overall goals of the course is aligned with the course activities, and the exam, in order to optimize the deep learning of the student. The result should ultimately be an increased learning outcome, less students dropping out, and in general just a better atmosphere at a course that is well-aligned with the students own motivation and expectations.

My personal motivation for addressing this topic was instigated by experiencing difficulties in attracting enough students to a new course I tried to launch at the Natural History Museum of Denmark (NHMD), where I am employed as an assistant professor. The museum acts as an institute under The University of Copenhagen but we are not heavily involved in teaching for example Biology and Geology students at undergraduate level. Instead the majority of the basic courses are being taught at other institutes. This implies that NHMD does not have a natural recruitment-flow of students to all the optional course we offer at both B.Sc. and M.Sc. level and therefore have to rely more on finding new niches and specifically tailoring courses that are not already available elsewhere. I, and other early-career scientists at NHMD, who are being at least partly evaluated by our ability to successfully establish and run university courses, have come to realize that this can be a considerable challenge.

Therefore, I decided to investigate which factors determine course selection when our students assemble their education. I figured that by obtaining a better understanding of their motivation and background, I could become better at designing new courses to meet the expectations and requirements of the students. From a less self-centred viewpoint, understanding the students motivation could obviously be helpful also on much broader terms, with the ultimate aim of creating a better and more relevant education for the students (Johannsen, Ulriksen, & og Holmegaard, 2013).

Methods

The input for this assessment was collected by two means. First I engaged in informal ’interviews’ with two highly experienced lecturers, namely Assoc. Profs. Anders P. Tøttrup and Anders J. Hansen, who act as our respective directors of Education and Science at NHMD. These interviews served merely as background research in order to understand the situation and teaching history at NHMD, allowing me to ask the right questions in subsequent questionaires to the students.

As for the actual investigation of student motivation, I designed a 1-page questionaire that was handed out to students at two courses at NHMD. The questionaire was divided into three parts (see Appendix A). The first question simply asks to the education of the student (for example *"Biology at Copenhagen University, M.Sc. level"*). The second part represents a quantitative approach, requiring the student to rate (1 to 5) the importance of nine different factors that may affect their motivation for selecting a particular course. The nine rated factors are: 1) Interest in the topic; 2) The reputation of the course; 3) The number of ECTS points; 4) Logistics in relation to other aspects of private/professional life; 5) Career opportunities; 6) Which institute is offering the course; 7) Who the teachers are; 8) Expected work load; 9) Social aspects (i.e. fellow students at the course). Lastly the students are encouraged to mention aspects that might be missing from this list. The third part of the questionaire requires the students to express in their own words a) Their main motivation for selecting the current course; b) If they had already heard about the course from fellow-students before signing up; and c) To what extent the online course description influenced their decision. The questionaire is included as Appendix A.

The questionaires were then handed out to a total of 35 students, representing two ongoing optional courses at NHMD, namely *'Origins'* (http://kurser.ku.dk/course/nbia09033u) and *'Forensic GeoBiology'* (http://kurser.ku.dk/course/nnmk13003u/). These courses are relatively successful in terms of student numbers why understanding the students underlying motivation for selecting these courses seems highly relevant. Given the relatively small number of observations, there is not basis for a detailed statistical evaluation of the results, which are merely summarised in figures and qualitatively discussed. This should be regarded as a pilot-study, probing the potential for a larger investigation of student motivation.

Results

Initial interviews and working hypotheses

The conversations with the two NHMD lecturers will not be reproduced here but I will just briefly discuss two aspects that was highlighted during these conversations. The first aspect, emphasized by both of them, was that the students they encounter when teaching typical M.Sc. courses at NHMD (mainly Geology and Biology students) seem to generally be driven by a genuine interest in the topic of the courses they have signed up for. It is not unexpected that students who have succesfully made it through their first couple of years at university have a genuine interest in the topics they select, but nonetheless this calls for a working hypothesis, namely that the *Interest in the topic* aspect will receive a high ranking from most students when they fill in the questionarie.

The second aspect worth noting is that one of these courses (*Forensic GeoBiology*) has experienced a highly positive trend in terms students signing up since its beginning. The approximate year-to-year increase in numbers over the past five years is observed as 6, 9, 12, 18, 27 students signing up. This increase has occurred without any significant changes to the course design, the timing of the course, or the course description. Therefore, the working hypothesis is that at least for this course, a lot of the motivation for signing up must come from the course gaining a good reputation, and the students are hearing about it from their fellow students who had the course in previous years. In contrast, the other course *Origins* has experienced a negative trend with less students signing up in recent years.

The students

A total of 35 students enrolled at the Science Faculty filled in the questionaire, 20 of them assigned to *Forensic GeoBiology* (2-week M.Sc. summer course in week 34-35) and 15 to *Origins* (B.Sc. course in block 3). The students background (discipline and level) is summarized in Table 1.1, and it is evident that the composition of students differs a bit between the two courses. However, unless where highlighted in the text the results from both courses will be discussed combined.

Rating the motivation

When examining the distribution of motivation scores (1 to 5) for each of the nine categories (Figure 1.1) it is clear that one category in particular stands out by being assigned the highest score from many students, namely the *'Interest in the topic'* category. Similarly, one category stands out with a relatively high proportion of students selecting the score 1 (not important). This is the category of *'Which institute is offering the course'*,

Table 1.1: *Background* A summary of the university background of the 35 students included in this investigation.

Forensic GeoBiology	
Biology, BSc	5
Biology, MSc	3
Biotechnology, MSc	8
Molecular Biomedicine, MSc	4
Origins	
Biology, BSc	6
Biology, MSc	1
Geology, BSc	6
Computer Science, BSc	2
Total	35

which is clearly not an important consideration when students are selecting their courses. The differences in motivation scores between the nine categories become easier to observe and quantify when the sum of all motivation points is calculated for each category (Figure 1.2). Again here, it is very clear the the *'Interest in the topic'* category with a total of 168 motivation points is the single most important factor (of the ones included in the study), when these students are selecting their courses. *'Course reputation'* and *'Career opportunities'* are both getting around 100 motivation points, whereas *'Logistics'*, *'Social aspects'*, *'Expected work load'* and *'ECTS points'* achieve in the range of 87 to 76 points. Two categories stand out with only 64 and 62 points, represented by *'The teachers'* and *'The institute'* offering the course. These are clearly the least important aspects, overall. As can be seen from Figure 1.1, the number of answers differ a bit between the categories. For example all 35 students have ranked the *'Personal interest'* category, whereas only 32 have ranked the *'Institute'* category. Obviously this will have an affect on the sum of motivation points depicted in Figure 1.2, but not to an extent that influence the main conclusions.

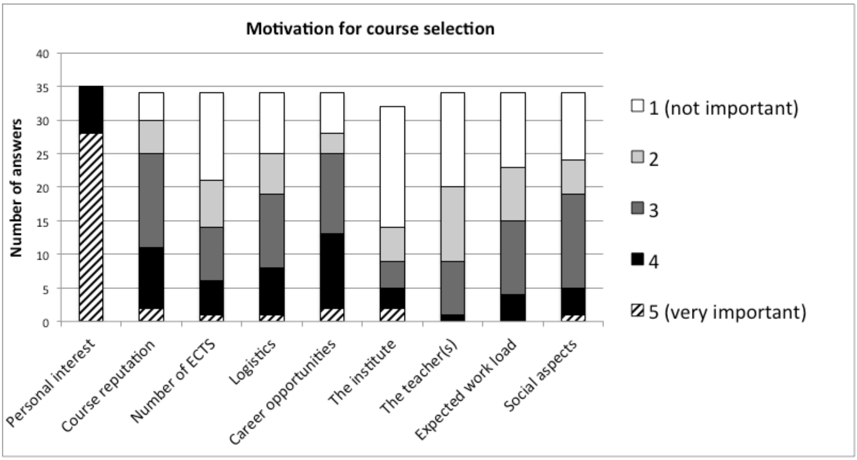

Fig. 1.1: *Overview of motivation scores* A summary of the points assigned by the students for each of the nine motivation categories listed in the questionaire.

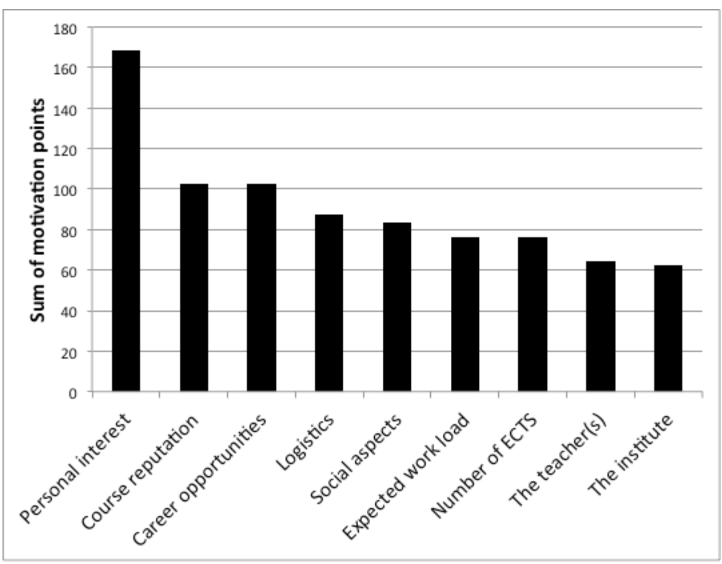

Fig. 1.2: *Sum of motivation scores:* The sum of motivation points for each of the nine motivation categories.

Other remarks

When addressing the question *"What was your main motivation for signing up to this course?"*, 30 of the 35 students (86%) apply words like *"exciting"* or *"interesting"*, clearly confirming that personal interest in the given topic is a major driver in selecting the course. Perhaps more surprising, 15 of the 20 students (75%) from the Forensic GeoBiology course, mention either the fact that they like the idea of having an intensive summer course, or something along the lines *"I needed 7.5 ECTS, and this was a brilliant way to get them fast"*. So clearly, for this course, the actual type of course and how/when it is executed, has certainly impacted its selection by the students. When addressing the question *"Had you heard about this course prior to reading the course description?"* a total of 20 students (57%) reply *"yes"*, and most of these have heard it from fellow students. In Forensic GeoBiology 12 of the 20 students (60%) confirms this, whereas slightly less (53%) in Origins course says something similar. When addressing the question *"How important was the course description in making your decision?"*, 25 of the 35 students replies in various ways that the course desciption had a lot of influence on their choice (nine students in Origins and 16 in Forensic GeoBiology). Conversely, this result implies that for roughly one third of the students, the course description has not been of major importance in their decision making. This is perahaps surprising given the considerable effort that is often expended in making these descriptions (Christiansen, Horst, & Rump, 2013).

Discussion

Although this assessment only manages to scratch the surface of a big and complex topic, several patterns have emerged. Most profoundly, it is clear that students at NHMD (at least within the two courses investigated here) are highly driven by their own interest in the topic. When it comes to selecting courses, personal interest is considerably more important than any of the other aspects offered in the questionaire - including career prospects. It is of course encouraging for any teacher to know that most of the students showing up to his/her classes will by default have a genuine interest in the topic being taught. This fact may offer more freedom and creativity for the teacher to break into new territory and, for example, dare to attempt a higher level of research-based teaching, which is an official requirement according to the Danish University Law (Bonderup & Dolin, 2013).

In terms of proposing and designing new courses, however, this high degree of *"selection-by-interest"* observed among the students could also impose a challenge. This fact might make it difficult to generate an interest for a new course if the course title or the description does not offer a direct link to a topic the students are already interested in. To stay in zoological terms, if only a 2-3 biology students per year in Denmark are intuitively interested in reptiles and amphibians, whereas a considerable proportion tend to have a fascination for whales, it is perhaps no wonder that the course *"Herpetology"* fails miserably when being proposed, while *"Marine mammals"* becomes an instant success. In those cases, it is clear that the course has to offer something else in order to catch the attention of the students and survive.

Fortunately, this little survey has shown that there are other cards to play. *Career prospects* is a relatively highly ranked category (Figure 1.2), indicating that if the course includes the acquirement of certain skills, eventually increasing the chance of getting a job, then it has a good chance of attracting students. Again, recruiting students should obviously not be the main motivator for designing a course, rather the learning outcome should always be in sharp focus. However, the high ranking of the *Career prospects* category emphasizes that these students are thinking much in terms of applied science. Thus, if the course cannot draw much attention based on sheer default interest in the overall theme, then it might be worth focusing hard on skill acquirement in favor of more classical academic knowledge. This point also emphasizes why asking the students about the motivation at the beginning of a course is a highly valuable excercise in order to achieve a more efficient constructive alignment of learning goals and course activities (Biggs, 2011; Mørcke & Rump, 2015). Many of the biology students may not care at all about reptiles and amphibians, but the general monitoring or molecular tools, potentially being offered at such course, could easily be in high demand among professional biologists.

Moreover, courses can build up a reputation over time, as observed with *Forensic GeoBiology* which has grown steadily over the past five years, and where 60% of the students reply that they had heard about the course from fellow students. This implies that it may easily take some years for a course to gain momentum. Initially, many students may not select the course if the title or the description do not appeal to their general interests. However, if the course manages to actually run, educating batches of satisfied students, then the word will start spreading and the course can grow from year to year despite perhaps not having a the most 'catchy' name. In that sense, it is clear that having students spreading the word is at least as important, as having produced an exciting course description. Also, it should probably not be underestimated that the type of course (i.e. summer course or regular course), the time of year, and the number of ECTS all play a role. According to the answers in the questionaires, *Forensic GeoBiology* is clearly benefitting from these aspects. Interestingly, ECTS and logistics do not score high when directly ranked by the students (Figure 1.2), but when asked to express their motivation in words rather than in numbers, 75% of the *Forensic GeoBiology* students highlighted these aspects as major points of motivation.

It is not suprising that the name of the institute hosting the course, and the teachers running it, are ranked with little importance when it comes to selecting a given course. On large institutions one cannot expect the students to know all employees, let alone their teaching and research reputation. But perhaps this result does indicate that there is some unexploited room for 'marketing' when it comes to branding the different institutes in terms of their peak competences, and which facilities and teaching opportunities that are hosted at the various departments etc.

Finally I note that these results should of course be interpreted with caution. This text is based on answers from only 35 students from a rather narrow set of disciplines within the faculty if SCIENCE at University of Copenhagen. Despite this caveat, this has been an enlightening excercise, providing insight into students motivation when they are selecting their optional courses at both B.Sc. and M.Sc. level. The observations discussed above are worth keeping in mind both when it comes to designing and 'selling' new courses but also when aligning the lectures and exercises with the expectations and motivation of the students, in order to ultimately maximize the deep learning outcome (Biggs, 2011; Mørcke & Rump, 2015).

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A

Spørgeskema i forbindelse med projektopgave på kurset *Universitetspædagogik* på Københavns Universitet, december 2017

v. Morten Allentoft

1) Hvilken uddanelse er du igang med og hvilket trin (f.eks. Biologi på KU, MSc)?

2) Ud fra hvilke kriterier vælger du generelt dine kurser?

Giv point fra 1 (**meget vigtigt**) til 5 (**ikke vigtigt**):

- Interesse i emnet:
- Kursets omdømme:
- Antal ECTS point:
- Logistik ift mit øvrige skema og liv:
- Karrieremuligheder:
- Hvilket institut der udbyder kurset (f.eks. Biologisk Institut eller SNM):
- Hvem der står som underviser:
- Forventet arbejdsbyrde:
- Sociale aspekter (f.eks. du kender andre, der også har valgt det):
- Evt et vigtig punkt der mangler:

3) Prøv at sætte lidt ord på følgende:

Hvad var den primære grund til at du valgte dette kursus?

Havde du hørt om dette kursus allerede inden du læste kursusbeskrivelsen, og i så fald fra hvem (medstuderende, andre undervisere etc)?

Hvor meget betød kursusbeskrivelsen for dit valg?

2

At gentænke et kursus med fokus på de studerendes motivation

Christian Mac Ørum Rasmussen

Statens Naturhistoriske Museum
Københavns Universitet

Motivation

Hvorfor er facebook vigtigere end det der foregår på tavlen? Omend dette spørgsmål som udgangspunkt zoomer ind på den enkelte forelæsning kan det måske også bredes ud over et helt kursusforløb. Hvad får de studerende til at brænde for et fag? Kan de inspireres i retning af underviserens forskningsfelt så denne gennem sin undervisning kan 'gøde jorden' til en fremtidig øget forskningsproduktion, eksempelvis? **Mit hovedspørgsmål i dette udviklingsprojekt er derfor Hvordan får man de studerendes engagement frem så det er vedblivende?**

Indledning

I foråret 2017 overtog jeg ansvaret for SNM's bachelorkursus i palæontologi. Kurset har fire lærere, er obligatorisk for geologistuderende og tilvalgsfag på biologi på 3. år. I forhold til fagets rammer er der således et godt, fagligt studentermiks på kurset. Da vi var tre nye lærere på kursus kunne det overdragede undervisningsmateriale ikke videreførers. Undervisergruppen blev derfor enige om at se kurset i et lidt bredere perspektiv – yderligere set i lyset af at faget palæontologi generelt har lidt kraftigt under KU's besparelser således at der nu kun udbydes to kurser i palæontologi på hele KU – begge bachelorkurser. Da kurset således er en unik chance for at indfange interesserede studerende forholdsvis tidligt i deres studietid ville vi ikke bare forsøge at engagere de studerende gennem motiverende undervisning, men også søge at inspirere dem til at overveje palæontologi som et reelt område at specialisere sig indenfor. Vi havde derfor en del didaktiske overvejelser som medførte at vi ændrede kursets læringsmål til mere at fokusere på metoder og principper i et anvendelsesmæssigt perspektiv båret frem af en dialog-og forskningsbaseret undervisningsform. I det følgende vil jeg beskrive hvorledes jeg gennem mit udviklingsprojekt har fået feedback fra de studerende specifikt med det formål at undersøge hvorledes ovennævnte tiltag påvirkede både deres læringssituation, men også hvorvidt disse tiltag har påvirket deres præferencer ift. senere specialisering indenfor palæontologi. Inden denne gennemgang vil jeg dog kort resumere hvad litteraturen foreskriver om emnet studentermotivation.

Resume af udvalgt litteratur

I forhold til dette udviklingsprojekt har jeg især været interesseret i hvordan man motiverer de studerende. Hvis man vil fastholde studerende i undervisningen handler det om at aktivere dem, at engagere dem. I universitetspædagogisk litteratur er dette ofte set som et spørgsmål om motivation (Biggs & Tang, 2007). Ifølge dem, er vi som universitetsundervisere nødt til at tilpasse os den hastige forandring som universiteterne har gennemgået de sidste 20 år. Fra tidligere at være elitære, akademiske miljøer, som tiltrak motiverede studerende, er universiteterne i dag et sted hvor masserne søger hen blot for at blive kvalificeret til et bestemt job. Biggs og Tang (2007) beskriver dette som Susan og Robert problemet, hvor Susan er den natuligt engagerede, der vil nå et dybt læringsniveau uanset undervisningsstil. Robert, derimod, er én der ikke umiddelbart ser noget formål med den undervisning han deltager i og derfor blot gennem udenadslære når et overfladisk læringsniveau. Skal Robert motiveres således at han når kursets læringsmål kræver det derfor en helt anden undervisningsstrategi fra underviserens side, en som aktivt inddrager Robert således at han er nødt til at stille spørgsmål ved, undersøge og spekulere over de ting han lærer. Derved når han et dybere læringsniveau som ligger tættere på det Susan fra starten har befundet sig på. Fænomenet er også kendt som intrinsic [iboende/ indre] og extrinsic [ydre] motivation (Bain, 2011; DeLong & Winter, 2002). Hvor Susan-typen er drevet af en indre motivation til at lære fordi hun synes det er relevant, er Robert-typen måske drevet af forældreforventninger eller specifikke karaktermål. Derfor har Susan fordel af en iboende, langvarig interesse som naturligt bevares, mens Robert har brug for en gulerod i form af eksempelvis gode karakterer for at kunne motiveres. For begge vil underviserens begejstring for faget hjælpe til at nå læringsmålene. En veldokumenteret metode til at mindske forskellen mellem Susan og Robert er ved at inddrage forskningsbaseret undervisning. Lærebogens kap. 1.2 (Bonderup & Dolin, 2013) taler om *enquiry-based learning*, hvor forskningsbaseret undervisning er en tilgang der stimulerer netop Robert-typen. Denne form for undervisning prioriterer de studerendes evne til at argumentere og fokusere på processer således skabende et motiverende læringsrum hvor de studerende selv søger dybere indsigt i stoffet. Thøgersen (2011) viderefører denne diskussion ift. studerendes motivation i relation til universitetsdidaktik specifikt set i forhold til et kursus der traditionelt er kendetegnet ved et højt frafald af studerende. Altså, et kursus man for at videreføre metaforen, kunne sige havde forholdsvis mange Robert'er. Som underviser kan man forsøge at opnå hvad hun kalder 'samskabelse af engagement' hvor motivation ikke kun skal ses som noget allerede eksisterende underviseren skal forsøge at ramme – altså hvis alle studerende var Susan-typer jf. Biggs og Tangs eksempel. I stedet bør underviseren tilrettelægge aktiviteter der styrker motivationen i samspillet mellem studerende. Eksempelvis ved at skabe undervisningssituationer der bringer den studerendes fremtid i spil så de tænker *"Det er seriøst det her, altså det er en vigtig del af, hvad vi skal kunne, når vi er færdiguddannede"* (Thøgersen, 2011). Altså motivation og engagement opnås ved at de studerende indser det anvendelsesmæssige perspektiv i undervisningen – at de selv kommer til at arbejde med emnet når de er uddannede.

Beskrivelse af udviklingsprojektet

Palæontologi er traditionelt et fag med meget udenadslære, hvilket kan være noget tørt stof. Vi ændrede derfor læringsmålene til at fokusere på metoder og principper fremfor taksonomisk udenadslære for derigennem belyse faget fra et anvendelsesmæssigt perspektiv. Vores engagement og begejstring for faget (og gerne vores forskningsfelter) skulle være en vigtig ingrediens til at motivere de studerende ligesom en meget afslappet atmosfære med gode grin og dårlige jokes skulle skabe et trygt læringsrum for også derigennem at højne de studerendes læring. Ydermere var undervisningen dialogbaseret med indlagte reflektionsspørgsmål i forelæsningerne for hver 10¬–20 minutter og øvelser hvor de studerende fik hands-on erfaring med fossiler, som de gennem forskningsbaserede case-studies skulle relatere til problemstillinger de havde lært om i forelæsningerne. Øvelserne foregik i grupper hvor biologer og geologer bevidst blev blandet. Slutteligt indlagde vi, lige før eksamen, en frivillig lørdagsfeltekskursion til Stevns Klint og Faxe Kalkbrud (næsten alle deltog) hvor vi bragte mange af undervisningstemaerne i spil i felten.

For at teste hvorledes disse tiltag blev modtaget, har jeg dels analyseret kursusevalueringerne, som ca. 35% af kursusdeltagerene besvarede (Bilag A), dels har jeg stillet 19 opfølgende spørgsmål som fokuserer på hvorledes ovennævnte undervisningstiltag indvirkede både på læringsmiljøet, samt om det havde en positiv indvirken på deres opfattelse af faget. Fem studerende besvarede disse spørgsmål (se bilag B). Da jeg ikke kan vide om der er et overlap mellem personer der har svaret på kursusevalueringen og de uddybende spørgsmål, har jeg forsøgt at stille spørgsmålene så de komplimenterer evalueringen bedst muligt.

Analyse og diskussion

Grundet den begrænsede plads vil jeg i det følgende fokusere studenternes feedback ift. deres vurdering af læringsudbyttet som følge af vores undervisningsstil, de didaktiske greb beskrevet ovenfor, samt hvorvidt dette har inspireret dem til at specialisere sig indenfor palæontologien. Analysen er baseret på A2 delen af kursusevalueringen, samt mine uddybende spørgsmål (Bilag A og B).

Specifikt hvad angår det afslappede læringsrum og underviserens rolle svarer samtlige at den afslappede, humoristiske undervisningsstil havde en direkte påvirkning på deres motivation under kursusforløbet. De oplevede alle at deres læringsudbytte steg, men i forhold til en mulig videre specialisering svarer kun én at det har øget interessen for faget på lang sigt. Til gengæld angiver alle at den måde kurset var skruet sammen på – altså primært de didaktiske greb – har haft en overordnet positiv betydning for deres tanker om faget. Endvidere får det flere til at anbefale kurset til andre. ’Gode og engagerede undervisere som i høj grad bidrager til motivationen’; ’Man er ikke bange for at spørge’, ’Man føler at man faktisk lærer noget af alt det han står og fortæller om’, er eksempler på disse positive tilkendegivelser. De fleste havde allerede en præference for faget inden kursusstart, men var stadig i tvivl om hvilken retning de ville gå i. Kurset overbeviste dem om at det er den vej de skal gå: *’Jeg blev kun endnu mere bidt af faget. . . jeg har fundet mit fag og min interesse’*, som én skriver. Især fordelingen med dialogbaserede forelæsninger med spørgsmål der tvang de studerende til at reflektere over det de havde lært undervejs i forelæsningen, kombineret med øvelser hvor de studerendes forskellige baggrund blev bragt i spil gennem gruppearbejde der fokuserede på at anvende fossiler i en forskningsbaseret sammenhæng, er virkeligt blevet modtaget positivt: *'Jeg synes palæontologi er det kursus jeg har fået næstmest ud af'*; *'Man sidder ikke og mister koncentrationen og samtidig bliver man tvunget til at tænke selv'*; *'Det var en fantastisk idé. Jeg tror aldrig jeg har fået så meget ud af gruppearbejde, som under dette kursus'*; *'Det var en kæmpe bonus at kunne udnytte hinandens viden'* – bare for at fremhæve nogle kommentarer.

Generelt er besvarelserne jo nærmest pinligt positive. Dette hænger utvivlsomt sammen med at begge spørgeskemaer kun er udfyldt af ca. 1/3 af kursusdeltagerene og det er derfor ikke utænkeligt at netop dem der har været mest positive også er dem der har haft *lyst* til at svare. Ikke desto mindre er der flere brugbare svar, hvoraf ovennævnte korte diskussion kun indeholder få. Personligt gjorde jeg en del for at vise interesse for de studerende – eksempelvis ved at blive i pauserne og snakke om løst og fast fra deres og min egen hverdag. Det ved jeg også de andre undervisere gjorde. På den måde blev der opbygget et tillidsforhold der også kunne facilitere samtale mellem de studerende fra de forskellige studeretninger – altså for at bruge Thøgersen (2011) – en slags samskabelse af engagement. Der var utvivlsomt både Robert- og Susan-typer på holdet. Men det var min klare oplevelse at netop det at jeg engagerede mig i de studerende, tog deres spørgsmål alvorligt og eksempelvis brugte hele undervisningslokalet i min undervisning alt sammen var med til at engagere hele holdet yderligere. Jeg synes derfor at vi lykkedes fint med vores strategi ift. at ryste støvet af faget palæontologi ved at vise hvor spændende faget kan være når man fokuserer på hvordan man faktisk arbejder som palæontolog.

Perspektivering

Dette udviklingsprojekt har fokuseret på hvordan man som underviser kan inspirere således at den studerendes motivation og engagement øges. Endvidere var det et mål at undersøge hvorvidt undervisningsstil og nøje overvejede didaktiske greb, såsom dialog- og forskningsbaseret undervisning, kunne påvirke de studerendes præferencer ift. en senere specialisering indenfor kursets fagområde. Min analyse tyder på at hvor undervisningsstilen spiller kraftigt ind på hvor engagerede de studerende er under selve kursusforløbet, er det i sær det øgede læringsudbytte, som opnås gennem de didaktiske greb, der påvirker den studerende i et længere perspektiv. Hvis man skal perspektivere på dette udviklingsprojekt er der således grund til at fortsætte alle de tiltag som blev indført i 2017, men i 2018 lægge endnu mere vægt på selve undervisningsstrukturen da det synes at være gennem det dybere læringsniveau den studerende for alvor fatter interesse for faget og derved inspireres til et vedblivende engagement der måske ender i en senere specialisering indenfor palæontologien.

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A

Bilag A

A2 Kursusevaluering

Du kan besvare evalueringen nedenfor. Hvis der er enkelte spørgsmål, der ikke er relevante, kan du undlade at besvare dem.

17 havde mulighed for at besvare dette skema.
5 har besvaret dette skema.
Svarprocenten er 29,41 %. : 5 / 17

1

1.1 Hvad fungerede godt ved kurset? Og hvad var grunden?

- *skift mellem forlæsning og øvelser/snak med sidemand fungerer rigtigt godt.*
  Man sidder ikke og mister koncentrationen og samtidig bliver man tvunget til at tænke selv.
  Realistisk antal sider læsning.

- *God sammenhæng mellem forelæsninger og øvelser. Strukturen med at have små øvelser mellem oplæggene fungerer rigtig godt, da det giver en helt anden kontinuitet end opdelingen af forelæsninger/øvelser, som ses i mange andre fag. Gode og engagerede undervisere, som i høj grad bidrager til motivationen.*

- *Mange fossiler er altid godt*

- *Jeg synes at underviserne gjorde et solidt arbejde med at holde kurset interessant. Det kræver jo en del - men de har været sjove, fyldt med god humor og energi, hvilket gør det mest lærerigt. Jeg mener at man bedst lærer tingene hvis det foregår under/i gode rammer. Der har været sjove indput, der har været tid til uddybning, de har inddraget alle til en slags klassediskussion når der var noget der skulle vises frem - alle nogle vildt vigtige faktorer i at have god undervisning. Og når ja, selv om den der skide projektør ikke helt virker optimalt, så har det slet ikke gået dem på, men de har gjort det til en underholdene ting. Alle ting har været gennemgået, hvilket jeg synes også er vigtigt, da man jo har brug for at vide om det man postulerer er sand eller om der er brug for rettelser. Jeg ved ikke med resten af de studerende, men jeg synes i hvert fald at Palæontologi er det kursus jeg har fået næstmest ud af - kun overgået af Zooarkæologi.*

- *God vekselvirkning mellem teori og praktiske øvelser. Øvelserne understøttede indlæringen. God struktur og kommunikation.*

1.2 Jeg vil foreslå følgende forbedringer (OBS! Kommentarer vedr. individuelle undervisere angives på evalueringsskemaet for den pågældende underviser)

- *Vi snakkede om at ændre fossilgennemgangene, så hele holdet sidder, evt. samlet om et bord, og gennemgår fossilerne med den respektive underviser. På den måde får alle gennemgået de relevante ting.*

- *Der mangler lidt sammenhæng mellem de forskellige undervisnings emne, bare hvis man kunne indføre det sådan helt generelt.*

  Øvelserne er lidt forvirrende, men det er et nyt team så måske derfor.
  Men ikke så meget Bents, de er relativt sammenhængende

B

Bilag B

Fokusspørgsmål ifm. UP udviklingsprojekt

I det følgende er hver af studenternes besvarelser farvekodet.

Didaktiske overvejelser ift. forelæsninger

Forelæsninger blev som udgangspunkt opbygget således at der var indlagt spørgsmål, opgaver, eller anden form for studenteraktivitet.

-Følte du at denne inddragelse resulterede i et højere læringsudbytte for dig?

Ja, det er rart at kunne arbejde med tingene med det samme/mens man kan stille spørgsmål til det. Det hjalp også til at forstå teorien lidt bedre for folk som er mere praktiske end boglige.

Ja, så man ikke sidder og går kold, fx. i andre situationer hvor der tales i 40 minutter.

Nej, egentlig ikke, men det var en god "pause" i undervisningen, som var ret koncentreret. Jeg er vant til at udskrive dias og tage notater på udskriften undervejs, det fungerer for mig. Det kunne jeg ikke, da I havde valgt først at lægge dias op bagefter.

Ja helt sikkert. Jeg synes det giver en bedre forståelse for hele emnet, når man bliver sat til at reflektere over de ting, der er blevet sagt i løbet af forelæsningen. Nogle gange kan de svære ting også bedre forstås, når vi høre definitionen fra nogle medstuderende, der kan sige det med vores ord og forståelse.

Øget studenteraktivitet synes jeg er en rigtig god ide som gør det nemmere at lære ting i modsætning til old school forelæsninger hvor forelæseren snakker i 3 timer.

-Hvordan var mængden af forelæsninger kontra mængden af øvelser?

Flydende overgang mellem forelæsning og øvelser kan godt virke lidt forvirrende, men det passede meget fint ift mængdefordelingen.

Passende synes jeg selv.

Det var passende. Det burde have været tydeligere, at øvelserne var eksamensstof.

Jeg synes det passede rigtig fint sammen. Det var virkelig rart at have så mange øvelser, så vi virkelig kunne sætte os ind i de forskellige emner. Forelæsninger har også en tendens til at kunne blive ret kedelige, mens øvelserne kan give et indblik i om vi som studerende egentlig har forstået pensum.

Kan ikke huske fordelingen så godt men jeg foretrækker klart øvelser fremfor forelæsninger da det er nemmere at lære ting hvis man arbejder med dem. Nogle forelæsninger er dog nødvendige for at etablere basisviden til øvelserne.

Didaktiske overvejelser ift. øvelser

-Hvad synes du om undervisningsformen med mest muligt praktisk indlæring (eks. at kigge på fossiler med henblik på palæøkologisk tolkning eller inddragelse af software til statistisk behandling)?

Det er en smule sjovere fordi det er lidt mere 'hands on' men samtidig er det også godt at vide hvad man gør med data efter den er indsamlet.

Jeg forstod dog aldrig helt den der graf vi lavede, for det var lidt svært at sætte navn på akserne og hvad det betød.

Fantastisk, idet man får en smule hands-on med at se hvad det er man evt. senere skal lede efter.

Helt nødvendigt at se på fossiller til et sådant fag!

Det virker som en rigtig god idé. Jeg synes det var ret svært at forstå meningen med nogle af de praktiske øvelser da vi brugte software. Jeg havde svært ved at se hvad jeg skulle bruge det til. Men for at vise hvilke arbejdsmetoder der bruges indenfor palæontologien kan jeg sagtens se logikken.

Jeg synes undervisningsformen var fantastisk det var rigtig fedt at kigge på fossiler og arbejde med software til databehandling.

-Hvordan fungerede det at arbejde i små grupper under øvelserne?

Godt, hvis man har venner, ej, det var meget fint, og det var rart at kunne vokalisere hvad man havde forstået, for det vi var ikke altid enige.
På den måde fandt jeg et par gange ud af, at jeg egentlig havde misforstået noget.

Udemærket.

Godt.

Det er super fedt som biolog at kunne spare med geologerne. Jeg fandt frem til nogle meget spændende diskussioner, hvor tværfagligheden satte nye tankegange i gang. Derudover har jeg også i mit arbejde med palæontologien senere hen, fundet ud af hvor vigtigt det er at kunne spare med andre, og sammen komme tættere på det egentlige resultat.

Gruppearbejdet fungerede godt da man kan få diskuteret ting man er i tvivl om i stedet for at sidde alene med det og måske ikke ville spørge om det.

-Hvordan fungerede det når biologer og geologer bevidst blev sat sammen i grupper?

Det var en kæmpe bonus at kunne udnytte hinandens viden, især fordi biologerne havde set mange ting før, sås om fylogeni-træer o.l., som vi ikke havde så meget viden om inden kurset.

Det var tydeligt hvem der vidste hvad indenfor de forskellige emner, men sådan kan man også lære af hinanden.

Rigtig godt, det var godt og lærerigt!

Det var en fantastisk idé. Jeg tror aldrig jeg har fået så meget ud af gruppearbejde, som under dette kursus. Jeg som biolog, synes det var super fedt at arbejde sammen med geologerne, der havde styr på de grundlæggende ting indenfor geologien, jeg ikke ved noget om. Jeg ved også at geologerne nogle gange synes det var rart at have en biolog i nærheden, når de kom på dybt vand.

Gruppe arbejdet mellem geologer og biologer var en god ting da begge dele ved ting de andre ikke ved og derfor kan hjælpe hinanden.

<u>Generelle overvejelser om kursets struktur og opbygning</u>

Kurset var opbygget af syv moduler der nogenlunde reflekterede den øgede kompleksitet i livets udvikling – altså startende med invertebrater og sluttende med vertebrater.

-Hvordan fungerede dette i praksis for dig som studerende?

Det lagde jeg ikke rigtig mærke til at det var, sorry! Så der er jeg ret neutral.

Men så kunne det være fedt med lidt flere dinosaur? Kan i ikke overtale Jesper Milan til at komme 1 time og snakke lidt om dem?

Og så lige skrive til mig inden så jeg kan liste mig med til forelæsningen ;)

Som biologistuderende synes jeg det var en passende udvikling. Man starter småt og bygger videre - sådan burde det generelt være.

Det var meget koncentreret. Det var for mange dias i jeres forelæsninger og også for meget overlap.ellers var det fint bygget op!

Det fungerede så fint at hele jordens historie blev gennemgået kronologisk, så man bedre kunne følge med. Den lange planche vi lavede undervejs, blev med tiden fyldt mere og mere op. Det var rigtig godt at vi ikke fik kastet det hele i hovedet på en gang. Det havde været alt for uoverskueligt. Så en rigtig god idé at tage det stille og roligt og Jordens historie i kronologisk rækkefølge med det ældste først.

Opbygningen af modulerne gav et fint indblik i evolutionen og kompleksiteten af forskellige organismer.

-Var kurset skruet sammen på en sådan måde at du fik udbytte af det og måske lyst til at lære mere om palæontologi?

Ja! Men jeg har også været interesseret i længere tid, men det med at se alle de forskellige afgrene indenfor palæontologi var ret sejt!
Især det med diatomeer var ret nyt, og ikke helt noget jeg vidste eksisterede, altså læren om det, inden.

Ja, helt bestemt. Der var mange ting jeg gerne ville lære mere om.

Det var et godt kursus! Jeg overvejede sågar at skrive bachelor i faget, men har valgt noget andet alligevel. Ville gerne tage flere pal-kurser.

Jeg er kun blevet endnu mere bidt af faget, end jeg var inden kursets start. Jeg prøver så vidt muligt at fortsætte i palæontologien. Jeg har fundet mit fag og min interesse.

Jeg tror jeg er maxet ud på lyst til at lære mere om palæontologi, men jeg fik meget ud af kurset især de øvelser hvor vi brugte software til at analysere fossil data, da det virkede som faktisk palæontolog arbejde.

-Blev det tydeligt nok forklaret af underviserne at fokus var på processer og metoder frem for udenadslære?

Det har jeg ikke bidt mærke i, men det kunne være fedt hvis havde fokuseret lidt mere på de miljøer, i alle aspekterne, som de forskellige fossiler kom fra, for tit blev det til at man gik op og kiggede på bordet den sidste halve time og der kunne det havde været godt med lidt mere inddragende undervisning.

Men det var meget rart at i fokuserede mere på at vi vidste hvad det betød at man fandt de fossiler vi kiggede på, end at vi skulle kunne sige alle de latinske navne.

En lille smule svært at svare på: Ja, det handler om at man kan bruge de værktøjer vi får, til at kunne bestemme sig frem til ting, men når det så er sagt, så er der virkelig meget som man også skal vide udenad, men mest for at det går hurtigere.
En eksamen i udenadslære ville heller ikke være særligt spændende, og den ville være meget kort..

Ja, men der forventedes alligevel udenadslære ved eks. Nu er det jo vigtigst at få lært noget - og det gjorde vi - end at få en super karakter. Det kan også være svært at afgrænse pensum i andre fag i forhold til eks., men det var mere uigennemskueligt i dette fag.

Jeg synes der var meget udenadslære, men jeg synes også at det blev gjort klart, at vi kunne argumentere for vores resultater. Så selvom det måske ikke var det underviserne ville have svaret, kunne det måske stadig diskuteres. Så det var ikke 100% klart.

Det kan jeg ikke huske desværre.

<u>Generelt om motivation for at følge undervisningen</u>
-Havde du en præference for palæontologi før du valgte kurset?

Ja, men jeg havde præference indenfor mange ting, så det var også lige for at se faget an, at jeg valgte det. Og fordi det egentlig havde været meget spændende på første år.

Nej.

Ja, lidt.

Ja, jeg havde en aftale om at skrive bachelorprojekt i Faxe Kalkbrud, så jeg var nødt til at have faget. Men det viste sig at være en rigtig god beslutning.

Ja

-Gjorde det mere anvendelsesmæssige perspektiv kurset mere interessant?

Jeg er ikke helt sikker på spørgsmålet, men jeg synes i var gode til at forklarer hvad de forskellige ting kunne bruges til i praksis.

Lidt. Jeg bliver nok ikke palæontolog, men det var stadig et interessant fag.
Hvad mener du med det??
Ja, det er altid interessant som studerende at forstå hvad de enkelte fag skal bruges til.

Ja

-Ændrede kurset din opfattelse af palæontologi i en mere positiv retning?

Den var allerede ret positiv, men ja, det udvidede i hvert fald min horisont inden for emnet over hvor bredt det egentlig er.

Haha, altså hvad angår den stereotype opfattelse?
Jeg tror at det med at "sidde i et stenbrud og slå ting i stykker med en hammer dagen lang" nok aldrig kommer til at ændre sig, specielt ikke mens Bent stadig er der.

Var meget positiv fra starten.

Helt sikkert. Jeg var ikke helt sikker på at jeg synes det var SÅ spændende. Men kurset fik mig virkelig overbevist om at jeg nok var mere interesseret i det, end jeg selv lige troede/ havde regnet med.

Ja

-Gav kurset dig mere eller mindre lyst til at specialisere dig indenfor palæontologi?

Altså, jeg regner med at skulle skrive hos Arne, men det hjalp da lidt. Eller også kan man sige at mit sommerkursus i hydrogeologi samt hydrologi i 4 blok gjorde at det i hvert fald ikke skulle være hydrologi jeg skrev indenfor.

Hvis jeg havde adgang til flere lignende fag, men det har jeg ikke.

Mere, men se ovenfor.

Det gav mig helt klart mere lyst til at skulle fortsætte i den retning, også på kandidaten (hvis det er muligt).

Ja

Underviserne anlagde bevidst en afslappet undervisningsstil med plads til dialog og humor (synes vi selv…;o)).

Det var super nice!

-Havde denne (humoristiske) undervisningsstil nogen betydning for dit læringsudbytte?

Det er lidt svært at svare på, men det at i skabte et miljø hvor i ikke bare råber NEEEJ! Hvis vi svare forkert, eller ikke rigtig tager i mod spørgsmål, gør at jeg havde lettere ved at stille spørgsmål, også selvom jeg måske følte at de ikke var de bedste, eller hvis det føltes som et lidt dumt spørgsmål.

Også det at i gik rundt under øvelserne og snakkede med os hjalp meget med at skabe et miljø hvor jeg ikke følte at i bare var der fordi i SKAL undervise, men havde en generel interesse i vores læring

Det at jeg kunne stille de her spørgsmål og snakke med jer om de resultater jeg havde fundet til øvelsen gjorde at jeg var en del mindre nervøs til eksamen, bl.a., fordi jeg havde fået en masse afklaring inden.

I DEN grad. I andre fag bliver det meget hurtigt dødsygt hvis lærerne ikke har en smule humor og selvironi.

Ja, det var sjovt og engagerende!

At underviserne også kunne joke og være nede på jorden, gjorde det meget mere afslappet og interessant. Jeg lærer bedst, når jeg ikke skal være ”nervøs” for at stille et spørgsmål, der måske kunne lyde dumt. Den afslappede undervisningsstil motiverede mig også til at ville lære mere. På den anden side var jeg heller ikke på noget tidspunkt i tvivl om forventningerne til kurset og eksamen.

Det synes jeg også. Den humoristiske undervisningsstil gjorde en forskel for læringsudbyttet da det er nemmere at høre efter hvis der er lidt sjov og spas og det havde klart en indflydelse på engagementet da man er mindre tilbøjelig til at blive hjemme og skippe undervisning hvis undervisning både er sjov og lærerig.

-Havde den betydning for dit engagement ift. kurset?

Hm.. Ja jeg tror faktisk jeg var mere aktiv ift spørgsmål og rent faktisk at deltage i undervisningen end normalt. Men det kan også være fordi jeg syntes det rent faktisk var interessant.

Ja, for når man har det godt, eller i hvert fald når man godt kan få et grin ind imellem, så trives man bedre. Det er så sandt som det kan siges.

Se ovenfor.

Ja. Det er der ingen tvivl om.

-Havde undervisningsstilen nogen betydning ift. til eventuelle overvejelser du måtte have om hvorvidt du i fremtiden vil specialisere dig indenfor palæontologi?

Ja, for i virkede en del mere chillern end mange af de andre undervisere vi har haft. Og som i jer alle sammen, så det var ret fedt.

Men ja, også det at vi kunne snakke med jer og hører om de forskellige ting i laver og specialiserer jer indenfor var en god faktor, i stedet for at man bare får noget af vide så som "Jeg har gravet rubiner på Grønland". Det hjælper også at i kombinerede undervisningen med nogen af jeres egne historier, som Christinas med hvordan hendes vejleder havde opløst et sjældent mikro-fossil fordi han havde brugt syre i stedet for vand.

Men jeg håber da at jeg kan, det lød nemlig på jer alle sammen som om at i virkelig godt kan lide det i laver.

Hvis man har garanti for at al palæontologiundervisning foregår på samme muntre niveau, så helt klart.

Det ved jeg ikke rigtig, måske!?

Det ved jeg ikke. Jeg ved at faget og undervisningsstilen har været med til at motivere mig til at fortsætte i denne retning.

Tror ikke jeg bliver mere tilbøjelig til at blive palæontolog fordi dig og Arne er sjove men jeg er i forvejen ret tilbøjelig til at blive palæontolog så det er måske bare mig. Når det så er sagt så er det nemmere at høre efter når underviserne ikke er så "tørre".

-Hvad tænker du vi som undervisere kan gøre for at højne den studerendes engagement?

Nogen gange var det en smule forvirrende, de der grafer bl.a.
Så måske at sørge for at ppt ikke er for lange (Det var i gode til, altså at de ikke blev for lange.)

Ellers så lidt flere øvelser, og ikke nogen vinterferie, den er lidt unødvendig når vi lige har haft mellemuge, og ubrugelig når vi ikke havde fri i de andre fag vi havde.

Jeg synes i var gode til at engagerer os, både til forelæsningerne og øvelserne

Være lige så åbne og imødekommende og engagerede som i er, så skal det nok gå.

I gjorde vist hvad I kunne😉

Fortsætte som I gør nu. Det er et rigtig godt kursus. Måske skal I gøre det lidt mere tydeligt hvorfor de forskellige metoder er vigtige at kunne arbejde med.

Det ved jeg sgu ikke

-Hvilke tiltag tænker du kunne gøres for at gøre kursus bedre fremover?

Jeg ved der er nogen som brokkede sig over at der ikke var flere dinosaur, men for at være ærlig går jeg ikke særlig meget op i dem, så mit forbedringspunkt ville være at i kunne prøve og indfører os i den taxonomiske beskrivelses metode. Det kan være et hvilket som helt fossil, en trilobit, en brachiopod, en alge, hvad som helt, hvor man lige prøver det – Det synes jeg kunne havde været fedt.

Og så ingen vinterferie, jeg ville hellere havde haft undervisning den uge.

Jeg havde nogen foreslag dengang jeg havde faget, men dem kan jeg ikke huske nu. Måske gerne lidt flere feltture? Eller måske et lokale der ikke var så lukket? Der var vidst også nogle stensamlinger, hvor vi hentede ting fra hvis det var nødvendigt, det kunne måske være interessant at blive introduceret til dem?

Lidt bedre koordinering mellem underviserne (især dig og Arne). Gerne udarbejde noter til øvelserne, små kompendier. I andre fag har jeg jeg haft glæde af sådanne, fx om isotoper, bestemte bjergformationer mv

Det er et meget godt spørgsmål. Jeg synes det var et rigtig godt kursus og super god undervisning. Det kunne måske være en idé at lave et projekt i løbet af kurset med en dyregruppe eller en periode man ønsker at beskæftige sig med. Det kunne være, man skulle finde ud af hvilke metoder der kunne bruges og hvorfor lige netop disse skulle bruges. Det kunne til sidst ende ud i en fremlæggelse for de andre på holdet.

Det ved jeg sgu heller ikke

-Hvad betyder noget ift. om du vil anbefale kurset til andre?

Jeg har anbefalet det til alle nye som har udvist bare den mindste smule interesse for pal, så der er ikke rigtig nogen, meget negative punkter for mig som ville gøre at jeg ikke ville anbefale det.

Men undervisningsformen gør også at det er lettere for mig at anbefale det. Men mineralogi (Udvidet) har jeg ofte sagt til folk, at det er spændende og sjovt, MEN! Man skal forberede så på meget udenadslære osv. Det har jeg ikke skulle her (Medmindre de har været mega interesserede i dino'er)

Helt klart undervisernes mindset hvad angår de studerende. Der er jo en masse ting der skal læres, men det mindste man kan gøre, det er at prøve at snige noget morskab ind i det, så bliver det straks meget mere tåleligt. Det er vigtigt at man møder undervisere der tænker "det her er det allerbedste fag, og jeg skal vise jer hvorfor" - hvor underviserne nærmest er i ekstase, uden at det er overdrevet. Der skal jo også være grundlag for beskyldninger, ikke?
Jeg synes helt klart at faget var underholdene, modsat mange andre fag der godt kan trække tænder ud.

Undervisningen skal være engagerende, formidlingen god, niveauet passende og så skal det være relevant for geologien. Alt var opfyldt hér😊Jeg har iøvrigt selv fået kurset anbefalet.

Undervisningsstilen, seriøsiteten på kurset, tværfagligheden. Og det er jo palæontologi, så jeg ville anbefalede det til mine medstuderende på biologi.

Jeg synes det var et rigtig godt kursus så hvis jeg snakkede med nogen der var interesserede i palæontologi ville jeg klart anbefale det.

Part II

Rethinking lab work

3

Improving teaching in the laboratory by open questions: A case study

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Introduction

In the field of biochemistry and molecular biology the laboratory is the place where the science is converted from the ideas to reality. Lab exercises for students are therefore a crucial part for their development. In many cases the students enter the laboratory with high interest, where they believe to find a new world to satisfy their own curiosity and let them develop own creativity, critical thinking and team work. The laboratory should give the easiest way for the student's deep learning. There is no way for the student to fulfill the task without being active. Anyway teachers can often observe the situation: "hands on – mind off" (Rienecker, Jørgensen, Dolin, & Ingerslev, 2015). The reason causing this (kind of) situations might be a cognitive overload for the student. Modifying the observation of Johnston and Wham, (Johnstone & A.J.B., 1982), there might be different factors and combinations thereof: a) unfamiliar environment and actions: the student enters with the laboratory an unknown room with specialized equipment and behaving rules, like safety issues. especially in facultative courses a new social environment could also occur on top. b) untrained manual skills to perform the experiments. at the same time the student needs to self-reflect on his own actions. c) transfer of theoretical knowledge and resulting imaginations of the experiment with the reality and d) keeping track of the expectations for the experiment and the scientific question the experiment should solve. The result is a micro-organizing student with the aim to fulfill now context-less step by step a given recipe – the protocol for the experiment – and leave the student on the uni-structural low level of understanding (see Structure of the

Observed Learning Outcome taxonomy (SOLO) Biggs and Tang (2007)). One way to reduce the student's cognitive overload is the preparation for the tasks before going into the laboratory (Tamir, 1989). Therefore in many cases the teachers prepare students beforehand with handing out the protocol and having colloquia to secure, that the steps of the protocol have been understood and the expectations for the outcome of the experiment are clear. Nevertheless, dependent on the type of colloquia, this might not support the student's overall development in learning how to think scientifically, improve the general ability to ask the right scientific questions, keep the curiosity and with this the motivation to do science or the general self-awareness. To facilitate this, Tamir proposed 1989 the concept of open questions. The idea of this concept is quite simple. The open questions demand from the student a self-elaborated and comprehensive answer. These answers can be demanded on the level of the scientific problem (what scientific question needs to be answered), on the level of "ways and means" (how can we answer the scientific question), and on the level of the answer (what is the answer?) and different combinations thereof (table 3.1). I was interested if it would be possible to improve my own teaching by open questions. Therefore I applied open questions for a preparation session for the laboratory during a summer course. To get a better feeling if the open questions indeed would change the overall learning outcome, I compared it to closed questions approach for the laboratory preparation during the same summer course.

Table 3.1: (according to Tamir (1989)): Level of openness in teaching in the laboratory

Level	**Problem**	**Ways and means**	**Answers**
0	Given	Given	Given
1	Given	Given	Open
2	Given	Open	Open
3	Open	Open	Open

Background, materials and methods

The comparison between the open question approach and the closed question approach was carried out during a two weeks summer course at the department of Plant and Environmental Science (PLEN). The summer course had the topic "protein biochemistry" and was on the master's level. . Six

Danish students from different study programs -nanotechnology, biotechnology, biochemistry and biology – participated in the course. This reflects a quite diverse background in knowledge and experience for the students regarding their experiences with the laboratory work. During the course the students worked on different scientific topics, where they needed to elaborate different biological questions. The topics were integrated in ongoing research projects at PLEN and had their focus on methods for the identification of protein interaction partners and complexes. The students needed to learn to perform the different methods in the laboratory. In the end of the course the students were examined separately based on their performance during a presentation in a wrap up session, and a report of the different experiments.

To perform my study of the comparison between the open question approach and the closed approach, I gave a lab preparation session, where the students were supposed to develop their own protocol (open question approach) and another session, where they had to discuss about a given protocol (closed question approach). The sessions took place at different days for different experiments. To point out, these experiments have no connections for their knowledge background and the master students have their basics in their laboratory experience, it was not possible to take advantage from the first experiment for the second one. Observations during the lessons of the two different approaches were done by me and by two visitors (either my university pedagogical supervisors or colleagues). For the evaluation of the two approaches I took the observations from the lessons, but also the students' performance in the lab, their performance during the presentation of the wrap up session and their method knowledge by two questions in a written exam like form, although they were informed it is not an exam. The written reports were not taken into consideration, because they were only partially evaluated by me. In the lab I focused on the following points: a) how do the students act in the unfamiliar environment with new equipment and colleagues from different study programs? b) How are they performing manual skills and self-reflection on their own performances, c) How do they cope with the transfer of theoretical knowledge and resulting imaginations of the experiment with the reality. The evaluation for the wrap up session was done by judgement for the completeness and clearness of the students' explanations according to their slides, whereas the answers of the written knowledge questions were simply quoted as right or wrong. Finally the students were asked to fill out a questionnaire, what they preferred as preparation for the lab and their impression which approach gave them a stronger learning outcome.

The structure of closed question approach: Epitope based affinity purification

Intended Learning Outcomes:

- How to perform the method
- What are the functions of the single steps of the method and which are critical
- What results can we expect from this method and how can the results be interpreted

Lesson design for the closed approach. Remark: The students needed to read through the protocol before the session and note questions

Table 3.2: the course design for the closed approach.

Devolution	Questions for the protocol	Group work students	1 min
Action	Writing the questions for the protocol on the board	Students	4 min
Institutionalization	Answering the questions	Students - support teacher	5 min
Devolution	Task for the students to explain the single steps of the protocol	Teacher	1 min
Action	Going through the single steps of the protocol, discussion which steps are made why	Group work	15 min
Institutionalization And summary	Evaluations and clarifications for the protocol	Students together with teacher	10 min
Devolution	Handing out the task to find the chemicals and consumables needed for the experiment and the safety rules belonging to them	Teacher	1 min
Action	Finding the chemicals and safety instructions	Group work	8 min
Break!			15 min
Lab			
Action	Prepare the buffers, familiarize with the equipment and follow the protocol	Group work 3x2 students/ teacher supervision	15min 3x5 min (5min for each group)
Institutionalization	Sum up of the morning		10 min

In this case the idea was to activate the students for deep learning by the discussion together about a known protocol. The “problem” as well as the “ways and means” and the “answers” are predefined and can be checked up in material from the lecture given beforehand. Therefore the approach is fully closed.

The structure of the open question approach: identification of proteins by mass spectrometry based proteomics

Intended Learning outcomes:

- How to perform the method
- What are the functions of the single steps of the method and which are critical
- What results can we expect from this method and how can the results be interpreted

Lesson design for the open question approach.

Table 3.3: the lesson design for the open question approach.

Devolution (introduction)	Handing out the task to design an own protocol to identify proteins by mass spectrometry	teacher	1 min
Action (introduction)	Based on the lecture given before (Tuesday Wednesday) Goal: To develop an own protocol for the identification of proteins	Group work in 2x3 people groups/exercise	15 min
Action	Puzzle pieces with true steps of to get it so they can combine them to their own protocol and supporting questions	Group work	10 min
Institutionalization And summary	Discussion of the now written maybe different protocols with the whole group/ comparison (why are which steps needed, what do we expect to get with this protocol, what might be the biases)	Students with teacher	10 min
Action	Make a list of all chemicals and equipment what is needed	Group work	5 min
Break!	Printing out of the self-made protocols	Teacher	15 min
Lab			
Action	Getting the chemicals, and equipment, telling me how to proceed and where to proceed	Group work 3x2 students/ expert participant teacher	15min 3x5 min (5min for each group)
	Following the self-made protocol in groups 3x2	Group work 3x2	1,5 hours
Institutionalization	Sum up of the morning		10 min

The open question approach was based on the idea that the students should be activated by the task to create their own protocol for the identification of proteins by mass spectrometry. Therefore the problem was given. Anyway the “ways and means” and also the “answers” were kept as “open” in the beginning. It was designed like a riddle, were they could ask for more and more information. In the beginning they had only the lecture material to decide what kind of method they would like to take. They could get then according to the chosen method a puzzle with headings of the single steps in the protocol (figure 3.1a). The number of puzzle pieces and headings were random but outnumbering the necessity of any protocol and the students were informed about that. As a further step they could get written supporting hints (figure 3.1b), but of course were also allowed to discuss with me. As last step they would get again as puzzle detailed descriptions of protocol steps, which they could align with their previous protocol steps or reconstruct their protocol according to the new information. With this the student decides how open or closed he/she would like to work. The aim was in the end to get a protocol they could follow and being prepared to perform the steps of it.

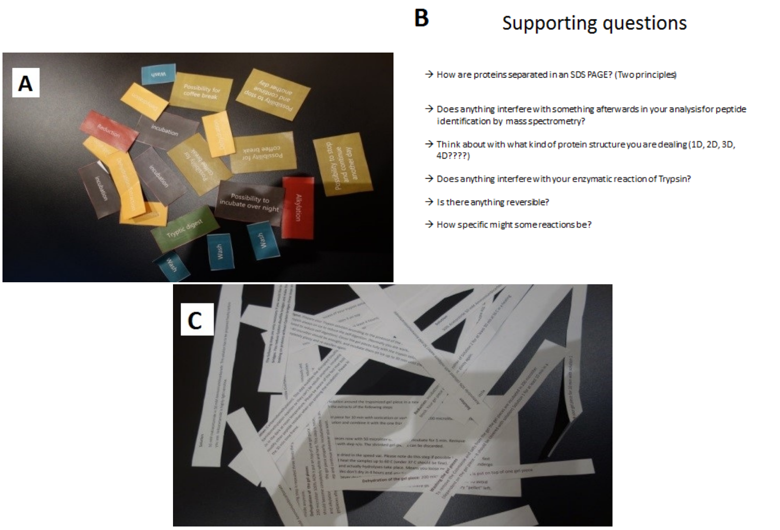

Fig. 3.1: Supporting material A: Puzzle pieces for the different protocol steps B: Supporting questions C: Puzzle pieces with detailed explanation of the protocol

Observation for the closed question approach

The preparation part for the laboratory went overall as designed. The students participated actively to write questions to the board and discussing with each other possible answers. They also discussed to find the crucial steps in the protocol or the meaning. Nevertheless there were some important points for me. For example the time schedule for the lesson was not kept in full length, because the students had fewer questions than expected, or they decided “I think, it is enough we should know about, let’s move on” (student’s quote). This indicated in my opinion, their aim was to fulfill the tasks given by the teacher without larger motivation or self-interest in it. Moreover the students preferred in many cases the action of the teacher. So I was rather asked to explain several times the points than they would think a little longer. “I think we will manage”, was a final student’s quote of the preparation session.

During the work in the laboratory the students took low responsibility for their own work and showed a low self-reliance. A high degree of teacher’s supervision was necessary to proceeding in the protocol, like for example reminding them in which step they are now, or what they are doing. The interaction with their colleagues and the teacher can be seen by quotes from students: “what was meant again with…”, “how have you done this step?”, “what do we need to take first now?” They were therefore fully focused on the handling of the experiment and the teacher sometimes needed to provide the connection between the preparation session and the laboratory work. During the summary session at the end of the, they were able to recall the important functions of the protocol and the functions of the steps, but had problems with the interpretation of the results. We could conclude therefore: the intended learning outcomes were reached to a high extent but not fully satisfactory. Actually this impression was confirmed during the presentation of the wrap up session, where they were able explain very clearly, what they have done, but couldn’t comment on the bottlenecks and restrictions of the method and had problems to answer critical questions about their results. The students showed the same tendency in the written exam questions, despite the fact, that during the summary and the wrap up session the points had been repeated. The question about the importance and crucial steps in the protocol was answered by 4 out of 6 students, with at least one right answer. The question for the preliminary results from the experiment could only be at least partial answered by 2 out of 6 people.

Observations for the open question approach

As for the closed question approach the preparation part for the laboratory by open questions, went in general like designed. Important points to mention are the following: The time frame for the full open question was too much. On the opposite side, the given time for the puzzle and the supporting questions was not enough. The latter took nearly twice as long. The students did not keep the discussion of small groups about the supporting material, but independently extended to discussions between the different groups. Moreover dialogue based support with the teacher was necessary and the students wanted to know actually the solution the teacher would choose. There was a true challenge for the students to fulfill the task (“I will never forget this”, one student said lying exhausted with his upper body on the table arms widely expanded). Nevertheless they worked hard on it and none of them lost the focus. Moreover they felt proud after having managed to get the protocol. A final quote of the session was: “Yeah, let’s go to the lab now”. For the work in the lab they took responsibility and started for example to self-organize between the groups. So they divided the task to make the buffers to be more efficient and loose less material. They seemed to foresee the steps, actions and even safety rules could be remembered, when asked for self-reflection by the teacher. Moreover they recognized quite often, when they had made a mistake. The questions they still had were more confirmation of their own thoughts instead of asking what they should think and I had even the time to coach the nanotechnology student, who was not on the same experience level in the lab than the others. In the wrap up session they gave a very detailed and comprehensive explanation of the method (- actually too detailed for the time frame they had-). The results were presented clearly and very self-confident. The written answers to the questions for the important steps in the experiment six out of six students came up with at least one of the right answers. The same is true for the questions about the experiment. Of course there were differences in the completeness of these answers, but all of them seemed to have kept something and the intended learning outcomes have been fulfilled.

Preferences by the students for one of the approaches

Actually the students preferred the open questions approach and especially the puzzle. All six students believed to learn more with the open question approach. Moreover they liked to develop their own protocol step by step. But they also believed that without supporting information it would not have been possible for them to develop anything. When they were asked for the support dialogue between the teacher and them, only one of the students wanted to have short and direct answers, the others felt well with getting additional open questions to let them think themselves further.

Evaluation of the open question approach in comparison to the classical approach

The two different approaches might have been influenced by day-dependent performance differences of the students and me. Additional some influence on the student might have been caused by me due to my excitement about the open question approach and how it would work. Nevertheless there are clear tendencies.

The two approaches started with the same basic intended learning outcomes: a) How to perform the method, b) What are the functions of the single steps of the method and which are critical c) What results can we expect from this method and how can the results be interpreted. Both approaches resulted in a similar learning outcome after the day in the laboratory regarding the basic knowledge about the protocol during the summary session. It differed on the level of interpretation of the results, where the open question approach resulted in a better outcome. On all further levels (the performance in the lab, the exams and the preference of the students) the open question approach outperformed the closed question approach. There might be various reasons, why the open question approach has caused this. The first one might be the different activation types of the students. The closed question approach caused an activity, without an authentic need for the student to be active. They could have followed the protocol without any of the activities and might have managed to perform the protocol, although the understanding would have been on a low understanding level (the unistructural level: identify, name, define mark, from the SOLO taxonomy, Biggs and Tang (2007)). Therefore it was greater effort for the teacher to get them on the level of the extended abstract understanding ("discuss, evaluate, create") and maybe it was sometimes even not possible, as we have seen by some of the students' quotes. The open question approach immediately leaded to a real authentic activity. The students would not have been able to continue in the laboratory without it. Therefore they were far more focused. And moreover it stimulated their ambition to manage the task. The possibility with the different levels of open questions seemed to provide them an environment, safe enough to proceeding, despite the challenge they felt to fulfill the task. In the end of the open question approach, they could give themselves maybe the best positive feedback they could get, a self-made protocol, which they would indeed apply in the lab afterwards. This in turn leaded to more self-confidence and a higher motivation to manage the tasks in the laboratory. The general cognitive overload during the lab-work seemed to be strongly lowered by the challenge during the preparation before. The possibility to take own time for the performance during the puzzle seemed to support that, too. Despite all positive observations, I have to mention, that scientific curiosity was an expectation not fulfilled during this session. They were rather busy with the challenge to get any protocol. Moreover they didn't want to try out different things in the laboratory. But I hope that the given puzzle provided somehow the way of general scientific thinking we are using every day as an example (combination of the different pieces, try out different connections and come to a preliminary conclusion). Therefore the open question approach seemed to provide an easy way for learning.

Finally we also might consider something else: the differences of teaching knowledge, skills and competences (Christiansen et al., 2015). The closed question approach acted mainly on the levels of gaining knowledge and skills. But being able to take responsibility in the laboratory, as we have seen in the open question approach, for the own experiment belongs to the field of competences. And the students started to take already to take responsibility after the preparation by the open question approach. This might indicate that open question approaches deliver far easier the way to competences than closed question approaches do.

Unfortunately and of course there are also pitfalls with the described open question approach. They need attention to improve the approach. In the given case, the open question approach can switch easily to a closed one. The reason is simple. The students know the fact that a perfect answer for the protocol exists and was performed millions of times by other researchers. The students can therefore redefine - and partially they did - the open question approach to a closed question approach by demand of the perfect solution from the teacher. This tendency might become more pronounced, when in the dialogue between the students and the teacher, the teacher does not find the right balance between answering their questions and keeping the open question approach on a higher order learning level with examining and challenging questions (Rosenkvist & Hansen-Skoevmose, 2002). To summarize this part: Overall the open question for this case study delivered the way to many good quality parts for teaching (motivation of the students, reducing cognitive overload, feedback, extended abstract understanding etc.), and learning. Nevertheless there might be the pitfall for the development to a closed question approach during the session.

Future perspectives and conclusions

This first attempt has shown the need to change the supporting material, the supporting questions and the time schedule. I had done this successfully in a second course after the herein described one (see Appendix A). This helped to keep the approach open from my side and gave the students more safety to get a good but flexible protocol setup. It might be possible in future to extend this approach to even larger classes (up to 25). In this case it might be necessary to include more peer review steps among the students instead of discussions with me. Moreover an expert protocol as comparison in the final institutionalization phase might be helpful. For classes larger than 25 people it would be necessary to program the puzzle as a computer game, so they can do it as an online group work and get feedback there. Of course there are also improvements possible for the described closed question approach. But the improvement possibilities for the open question approach might be still even more diverse. With this I would like to conclude that the described open questions had a positive impact on the laboratory work afterwards and the puzzle pieces facilitated the students' connections of the different steps in the protocol. But the puzzle pieces and the supporting material facilitate not only the understanding of the connections of the different steps in the protocol it also frames the topic the students are dealing with. This created on the one hand a safe environment for the students, where they couldn't fail to prepare their own protocol, but gives also the possibilities to the teacher to easily transfer it to complex and expensive laboratory experiments. (For example in this case the published expert protocol was the most expensive one, whereas all other possible solutions were cheaper). Of course there is a drawback for the teacher. The preparation for this approach is rather long. But in case of giving the course more than once, the time is refunded. Even when giving the course only once, the fun for the teacher to see to see the different discussion points of the student to approach a protocol and the different protocol possibilities might give enough reimbursement to go for it.

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A

Supporting questions

What are the challenges of each method (top down/in solution/in gel)?

What are the advantages of each method?

Maybe the following questions help you to decide

How many proteins are in your sample?

Do you remember the different spectra from the ion trap? What could be the challenges?

What kind of challenges does an enzyme have?

What might be biasing when you use an enzyme?

What are the substances inside a gel separation you might deal with?

What are the substances inside extracted proteins?

How do your proteins look like structure wise in a gel (might differ on the loading buffer)?

How do your proteins look like inside a protein extraction (might be dependent on the extraction)?

How can you minimize volumes of a sample? What might be the danger?

Supporting information

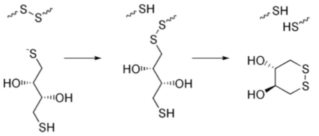
DMSO: Dimethylsulfoxide, organic solvent can be hardly evaporated

Acetonitrile: organic solvent; dehydrous

Trypsin: Serin Protease; cuts C-terminal at Arginine (R) and Lysine (K) sides in a protein except, when it is bound to a C-terminal Proline; Is pH sensitive

LysC: Endoproteinase; cuts C-terminal after Lysine (K) amino acids in a peptide. Although it has optimal pH range, it is a more robust enzyme than Trypsin regarding buffer conditions (8M Urea buffers possible). Moreover it cuts after Lysine despite Prolines.

Dithiotreitol DTT:



Iodoacetamide

Examples from the literature:

Top Down Proteomics: Facts and Perspectives

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Abstract

The rise of the "Top Down" method in the field of mass spectrometry-based proteomics has ushered in a new age of promise and challenge for the characterization and identification of proteins. Injecting intact proteins into the mass spectrometer allows for better characterization of post-translational modifications and avoids several of the serious "inference" problems associated with peptide-based proteomics. However, successful implementation of a Top Down approach to endogenous or other biologically relevant samples often requires the use of one or more forms of separation prior to mass spectrometric analysis, which have only begun to mature for whole protein MS. Recent advances in instrumentation have been used in conjunction with new ion fragmentation using photons and electrons that allow for better (and often complete) protein characterization on cases simply not tractable even just a few years ago. Finally, the use of native electrospray mass spectrometry has shown great promise for the identification and characterization of whole protein complexes in the 100 kDa to 1 MDa regime, with prospects for complete compositional analysis for endogenous protein assemblies a viable goal over the coming few years.

Quantitative Assessment of In-solution Digestion Efficiency Identifies Optimal Protocols for Unbiased Protein Analysis*S

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The majority of mass spectrometry-based protein quantification studies uses peptide-centric analytical methods and thus strongly relies on efficient and unbiased protein digestion protocols for sample preparation. We present a novel objective approach to assess protein digestion efficiency using a combination of qualitative and quantitative liquid chromatography-tandem MS methods and statistical data analysis. In contrast to previous studies we employed both standard qualitative as well as data-independent quantitative workflows to systematically assess trypsin digestion efficiency and bias using mitochondrial protein fractions. We evaluated nine trypsin-based digestion protocols, based on standard in-solution or on spin filter-aided digestion, including new optimized protocols. We investigated various reagents for protein solubilization and denaturation (dodecyl sulfate, deoxycholate, urea), several trypsin digestion conditions (buffer, RapiGest, deoxycholate, urea), and two methods for removal of detergents before analysis of peptides (acid precipitation or phase separation with ethyl acetate). Our data-independent quantitative liquid chromatography-tandem MS workflow quantified over 3700 distinct peptides with 96% completeness between all protocols and replicates, with an average 40% protein sequence coverage and an average of 11 peptides identified per protein. Systematic quantitative and statistical analysis of physicochemical parameters demonstrated that deoxycholate-assisted in-solution digestion combined with phase transfer allows for efficient, unbiased generation and recovery of peptides from all protein classes, including membrane proteins. This deoxycholate-assisted protocol was also optimal for spin filter-aided digestions as compared with existing methods. *Molecular & Cellular Proteomics 12: 10.1074/mcp.M112.025585, 2992–3005, 2013.*

analyzing medium to high complexity protein samples in large-scale proteomics relies on protein digestion by using the endoprotease trypsin. Analysis and sequencing of tryptic peptides by liquid chromatography-tandem MS (LC-MS/MS)[1] then enables identification and determination of protein expression levels based on the peptide ion abundance level or the (fragment) ion intensities of identified peptides. This peptide-centric approach thus strongly relies on efficient, unbiased and reproducible protein digestion protocols. Efficiency is required to maximize the number of detectable peptides per protein (coverage) to distinguish unique proteins within protein families with similar sequences and/or sequence variants, and to detect post-translational modifications. Unbiased generation of peptides is required for the resulting data set to most accurately reflect the relative (stoichiometry) and absolute protein abundance in a sample. A particular protocol should be unbiased with respect to abundance, molecular weight, hydrophobicity and protein class. Membrane proteins for example are often suspected to be underrepresented. For MS-based proteomics approaches several critical steps can be distinguished: (a) disruption and solubilization of cells and protein complexes, (b) protein denaturation and enzymatic proteolysis, (c) MS-compatible peptide recovery, which normally entails removal of reagent leftovers and desalting before MS analysis, (d) adequate peptide separation (achieved by liquid chromatography), and (e) MS peptide analysis and sequencing (MS/MS), including the chosen data acquisition strategy.

Comparative evaluations of digestion protocols generally consist of qualitative studies using standard tandem mass spectrometry. These approaches may reveal efficiency (*i.e.* more identifications), but are unable to reveal digestion pro-

PROTOCOL

In-gel digestion for mass spectrometric characterization of proteins and proteomes

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In-gel digestion of proteins isolated by gel electrophoresis is a cornerstone of mass spectrometry (MS)-driven proteomics. The 10-year-old recipe by Shevchenko *et al.* has been optimized to increase the speed and sensitivity of analysis. The protocol is for the in-gel digestion of both silver and Coomassie-stained protein spots or bands and can be followed by MALDI-MS or LC-MS/MS analysis to identify proteins at sensitivities better than a few femtomoles of protein starting material.

4

Tracking and supporting student learning in practical laboratory exercises spread over several days

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Introduction

In natural sciences, practical exercises including laboratory work are a central part of student education (Hofstein & Lunetta, 2004; Reid & Shah, 2007). Different aspects such as the level of education, (current) educational goals and the specific discipline have to be considered when designing meaningful laboratory exercises (Hofstein & Lunetta, 2004; Hofstein & Mamlok-Naaman, 2007). Even the relevance of laboratory exercises may vary in different disciplines, they are a suitable approach to combine various positive aspects: (1) students get the chance to connect theoretical knowledge with practical applications, and subsequently, to better internalize theoretical knowledge, (2) students have the indispensable possibility to gain hands-on experience in important methods they may need to address scientific questions later in their career, and (3) it is a good way to diversify teaching beyond lecturing and other theoretical teaching approaches which per se appears to be beneficial for (diverse) learners (Tanner & Allen, 2004). In particular, practical laboratory exercises have the advantage that they are based on a cognitive constructivism learning approach, which means hands-on experience in this context, following the theory of Jean Piaget (Dolin, 2015) which may be the only truly suitable way to convey practical skills in important methodologies to students in a scientific context. Laboratory exercises in biology courses typically foresee group work which spurs social interaction between students (Hofstein & Lunetta, 2004). Thus, this teaching format may additionally benefit from peer learning-based social constructivism following the theory of Lev Vygotsky (see Dolin (2015)) by elements of (1) more or less self-dependent coordination between different groups in the laboratory, and (2) coordination of work within individual groups and delivery of possible group assignments.

Although practical exercises are valuable tools in university teaching in natural sciences, planning and running such teaching units can be challenging. Especially when working with biological systems, the time course of experimental work can be quite lengthy which means that individual work steps of experimental approaches have to be spread over several days. Therefore, it is not enough that a teacher of such exercises gets information on the initial knowledge and preparation level of the students. It is necessary to assure a minimum of preparation on each individual day to maintain a meaningful exercise in the given time schedule, and that students are prepared when handling expensive and/or dangerous equipment and material in laboratories. Furthermore, the students' development in context of the course aims, their awareness of the current status of their work and their understanding of the dynamically developing content has to be observed and supported over several days. Only when students can keep track of the progress, i.e. the development of their experiments and connection between the individual course days, they have a chance to obtain a complete understanding of the work conducted during the exercise, and subsequently achieve the aims of an exercise or a course. Obviously, this appears to be more challenging in exercises that are spread over several days with possible gaps of few days in between than in short exercises conducted within one day. Considering these aspects, it may not be appropriate to (only) rely on tools such as online quizzes or instruction videos for preparing students outside the classroom. Therefore, reliable and efficient tools supporting a teacher in addressing these challenges in class to maintain a good and supportive learning environment for students participating in such laboratory exercises are very valuable.

Methodology

The challenging teaching scenario

In the study year 2016/2017, I took over the laboratory exercise "Tracking Gene Expression" from a colleague which is part of the course "Plant Genomics". This course is embedded in the BSc programmes "Biology" and

“Biology-Biotechnology” at the University of Copenhagen, Department of Plant and Environmental Sciences. Eleven students in their 2nd or 3rd year of BSc studies participated; for the laboratory exercise, the students were divided into four groups (three groups of three students, one group of two students).

Based on my experience in teaching this exercise the year before, I decided in agreement with the course responsible to completely change the programme of the exercise this time. This decision was based on student feedback from the year before and due to technical reasons (availability of material and equipment). Due to these changes, it was the first time that the exercise was taught in the particular laboratory and with this specific programme. In addition, I was largely lacking experience which level of background knowledge can be expected from the students attending this course. The new exercise comprised three individual experimental approaches with specific work step sequences. These approaches are used to analyse the same biological material that allows the correlation of results derived from the different approaches. The experimental work of the exercise is spread over three days with a gap of six days between the first two and the last course day in which students should do some calculations. As usually done, the students received written instructions including detailed laboratory protocols several days in advance and were asked to at least briefly go through them as preparation before the first day of the exercise.
Basic aims of the exercise are that students are able to:

- perform and understand the methods used in the exercise
- connect the individual work steps, i.e. keeping track of experimental work over several days
- understand the results including a basic interpretation
- understand the theoretical background of the methods (covered by accompanying lecture by another teacher)

Ideally, students should further be able to:

- judge the value of the obtained results
- correlate the obtained results derived from the three approaches with each other and subsequently make an advanced interpretation of the results
- transfer knowledge to decide which methods to use to address scientific problems in a specific way

A jointly developed flowchart as a tool in practical exercises spread over several days

Discussing the challenges of conducting this exercise (see above) with experienced colleagues, specifically the challenges

1. how to determine the initial levels and to assure a minimum level of preparation of the students in the beginning of the exercise and
2. how to keep track of their progress and to support them in an appropriate and dynamic way throughout the exercise to
3. achieve the course aims in terms of managing the practical work (in time) and understanding the basic underlying principles in the context of the whole exercise were identified to be the most critical. One suggestion was to implement a flowchart of the whole exercise which is jointly developed in dialogue with the students on a whiteboard in class. Following this, I developed a layout of a respective flowchart (Fig. 4.1) and an initial implementation plan (Table 4.1) for this exercise.

Student feedback

Considering the fact that this exercise was conducted the first time with this programme, it was the intention to get a very open basic feedback (by email or anonymously via Socrative; https://www.socrative.com/) on the exercise, for example what they experienced as (very) positive or what needs to be improved. Therefore, to avoid any bias, no initial request to evaluate the joint development and subsequent use of the flowchart was intended. Given the flowchart leads to the intended result to support the students in their learning and understanding, it should be named as a positive experience. In a second step, specific feedback addressing the flowchart may be requested.

Evaluation based on own experience

In addition to student feedback, the effect of implementing a jointly developed flowchart as a central element of the exercise was evaluated based on experiences from previous teaching of similar exercises, namely “Basic Methods in Plant Molecular Biology”. Important aspects of this evaluation comprise:

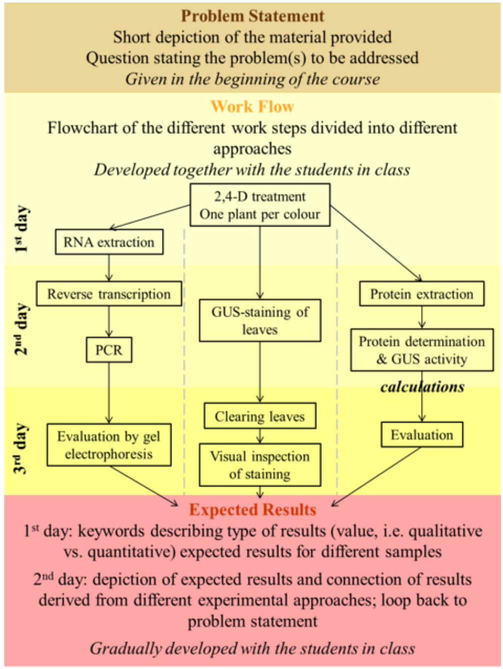

Fig. 4.1: *Outline of the flowchart as a central part of a practical exercise spread over several days.* The flowchart consists of three sections and includes the individual work steps of the exercise which are spread over several days. The first section is given in the beginning of the exercise and presents the problem statement, i.e. description of source material and the scientific problem to be addressed (brown). The second section describes the distribution of individual tasks over the course of the exercise, exemplified by the work steps of the laboratory exercise "Tracking Gene Expression" in the course "Plant Genomics" (yellow). In this example, the work is spread over three course days and split into three approaches leading to results of different value which are addressed in the third section that shows the expected results (red). The second and third sections are jointly developed in collaboration with the students during the exercise.

1. Estimation of student understanding of the content based on the final discussion of obtained results and case studies

Table 4.1: Implementation plan for a flowchart as a central element in laboratory exercises spread over several days.

Day of exercise	**Flowchart section**	**Action(s)**	**Intended effect**
1, Beginning	Problem Statement	Questions and discussion on source material and scientific problem in plenum. If no answers are given, buzz groups are initiated followed by plenum discussion.	Familiarize students with the basics of the exercise →avoids to early on lose students due to lack of initial understanding. Teacher can estimate the level of understanding and preparation of the students.
	Work Flow	Teacher guides through the different approaches, thereby develops individual work step sequences step by step in dialogue with the students. Includes questions targeting student understanding, i.e. question-answer sequences, buzz groups and discussions in plenum.	Familiarize unprepared students with the content and recapitulate content for prepared students and put the different work steps into context. Outlook on the upcoming workload. Teacher can estimate how far the students understand the concept of the whole exercise and which parts may need special attention.
	Expected Results	Questions on expectations regarding (1) concrete results of the individual approaches, and (2) value of these results. Can be supported by buzz groups and plenum discussion. Adding short keywords to the flowchart based on answers.	Short outlook on the results before starting the practical work.
2, Beginning	Problem Statement	Question on the starting point of the exercise and scientific problem.	Recapitulation of the exercise framework to set the scene and focus of the students. Teacher can check the understanding of the concept.
	Work Flow	Questions on the different approaches and the current progress, i.e. what has been done so far, what will be done on that day.	Recapitulation of previous work. Awareness/preparation of the work steps to be performed on the current day. Connection of the work steps conducted on different days.
Shortly before first results are obtained	Expected Results	Refining the expected results by illustrations depicting the specific results that will be obtain, e.g. colour staining.	Visualization of the results to support understanding and interpretation of the results. Preparation of students for the results from analyses they perform(ed) the first time → connect results with practical procedures. Looping back to scientific problem, i.e. why to expect certain results and what they would mean → connect results with scientific problem.
3, Beginning	Problem Statement	Question whether there are indications to answer the problem based on primary results obtained in the end of day 2.	Setting the scene again; initial connection of preliminary results and the scientific problem. Teacher can check the understanding of the concept.
	Work Flow	See day 2; extended by specifically addressing unclear or problematic steps/aspects retrospectively.	See day 2; extended by overall connection of previous work with the last work steps and upcoming results.
End	Expected Results	Guided cross-check of expected vs. obtained results. Discussion of the results and their value.	Validation of results. Clarification of unexpected results. Interpretation of results, connecting the information obtained by individual approaches.
	All sections	Final plenum discussion and recapitulation.	Connect scientific problem, methods and outcomes with the aims of the exercise to facilitate a holistic understanding. Highlight the need and value of the different approaches, i.e. which to choose to obtain what kind of information to solve a certain scientific problem. Clarify problematic issues connected to the exercise [→ also input for developing the exercise in future].
1 to 3	All sections	Spontaneous discussions between teacher and students or between students based on the flowchart. Individual students “consulting” the flowchart.	Reference point for orientation for students during the progress of the exercise and for exchange/discussions.

2. Quality of final reports submitted by the students
3. The teacher’s role and perspective on the exercise compared to similar exercises without using this tool

Optimizing the flowchart and its use

After evaluation of the exercise with a focus on the impact of using the flowchart as a central element of it, a plan to improve the flowchart and its use for the future will be developed.

Results

The jointly developed flowchart facilitates active communication and orientation

Despite lacking experience in whiteboard teaching, the concept of jointly developing a flowchart together with the students turned out to be very valuable for me to getting into dialogue with the students. As indicated in the implementation plan for the flowchart (Table 4.1), the exercise started with a discussion on the basic scientific question and source material. It was a natural process to allow students to discuss in buzz groups when questions seemed a bit difficult to answer due to different reasons which were (1) lack of preparation, (2) limited initial understanding of the topic, and (3) possibly initial reservations to speak in plenum. This initial phase was quickly overcome, and when jointly developing the work step sequences it became a relatively vital and interactive process between the teacher and the students compared to previous experiences. Thus, the jointly developed flowchart (Fig. 4.2) was a good initiation of the exercise by facilitating the interaction between the teacher and the students. As assumed, the first outlook on the "Expected Results" was somewhat limited as the students lacked the connection to the work steps which they did not perform yet. Nevertheless, when completing this section on the second day, it was obvious that priming this part on the first day was very beneficial for the students' understanding, although its implementation was not ideal - due to unexpected time issues; one student group that had some spare time was asked to make a suggestion on the flowchart which later was briefly discussed with all participants. Ideally, all participants individually or in their groups had to think about the illustration of the expected results before adding anything to the flowchart. Therefore, although the students still seemed to very well perceive and understand that part, its implementation needs some optimization.

Already during the exercise feedback from some students indicated that they are happy with this approach, having the flowchart step-by-step developed together on a whiteboard that stays in the laboratory. Thus, it served as a common basis of communication of the content of the exercise between the teacher and the students, but also between individual students. In addition, it was observed that students actively used the flowchart for their orientation. It also improved my confidence as a teacher running this exercise the first time, as I had the flowchart as a common basis to refer to which resulted in a better overview of the status and progress of the students, and

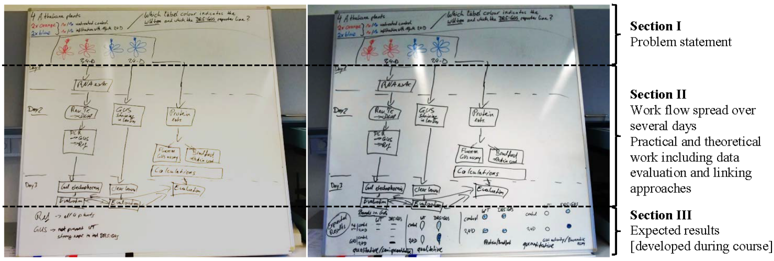

Fig. 4.2: *Flowchart jointly developed with the students in class*. The picture shows the flowchart after day 1 (left panel), and the finalized flowchart after day 2 (right panel) with the three sections corresponding to the scheme depicted in Fig.1.

which created a feeling of control, but also flexibility in running the exercise. Thus, the flowchart on the whiteboard facilitated a good "scientific" exchange between all participants in the exercise (including the teacher) as well as understanding of the content and the discussion partner.

Success of the exercise

A central part of estimating the success of the exercise was the final discussion of the results as well as discussion of case studies, i.e. published research using the methods that were performed in the exercise. Overall, the students were very well aware of the work they performed and the meaning and value of the results. They were able to recapitulate the individual methods, what they are useful for, and how they may complement each other. Furthermore, they could explain how the different results are connected, and how they may be combined to answer scientific questions on another (higher) level. When discussing the case studies, the students were able to transfer their knowledge on the learned methods to the presented research. While the basic understanding of their own work was much better than experienced in similar courses, it was the first time that I can say that the students were able to transfer their knowledge. In previous courses, this turned out to be a very critical aspect which is probably connected to the observed lack of basic understanding. The high level of understanding was in a similar way reflected also in the final reports which were in average on a better level than experienced before. Importantly, no group failed to describe the

Table 4.2: Compiled feedback referring to the used flowchart/whiteboard provided by students after class.

Responses by email	Student 1	Overview on whiteboard, nice structure of exercise
	Student 2	I really liked the flow chart and that you went through it so thoroughly. It gives a very good overview combined with the protocol.
	Student 3	Great with introduction to the experiment with board overview, but don't expect the students to have read for the next many lab days, usually we only read the stuff we are supposed to do for the day.
Anonymous responses*	Student 4	The flow-chart and the run-through created a nice overview of the exercise (very pedagogical)
	Student 5	White board layout, nice structure
	Student 6	Great with board overview before exercise
	Student 7 [*commented*]	The exercise was well described in the lab by Dominik, so there was no confusion. He was also very good at asking questions, so you had to think about some aspect you might not have thought about. *Teacher's comment: As these points were performed with the use of the flowchart/ whiteboard, this feedback can be regarded as a positive evaluation of this tool.*
	Student 8	I like the way you used the whiteboard to tell about the different results in the exercise. That made a good brush-up and was along a good learning point.

Students were asked to provide feedback on positive aspects and on points with potential for improvement of the whole practical exercise in general. All feedback related to the flowchart are included in the table.
*via Socrative; https://www.socrative.com/

work performed, to present the results and to provide valid interpretation. This means that all basic aims of the exercise have been achieved which was not all the time the case in previous courses. Instead, the final discussion and the reports highlighted very specific challenges in important steps of the process from the scientific problem to the results, namely certain calculations. A plan will be developed to address these specific challenges in future courses.

Students' perception of the flowchart

In addition to the in-class experience during the course of the exercise, the flowchart was often highlighted as a very positive aspect in the feedback provided by the students after completing the exercise. They were initially simply asked for feedback on aspects they perceived as positive and those that could be improved. Eight out of eleven students provided feedback of which seven named particularly the flowchart/whiteboard as the most (or one of the two most) positive aspects of the exercise, while one student referred indirectly to it (Table 4.2). This positive evaluation after class confirmed the very positive impression during the course of the exercise. Unfortunately, a second request for feedback specifically tailored to the improvement of the flowchart/whiteboard could only be sent in the very end of the course when the students were preparing and conducting their exams which resulted in no further input from the students. This specific aspect is planned to be taken up in future.

Discussion

The jointly developed flowchart supports student learning

The implementation of the jointly developed flowchart supported the students very much in achieving the primary aims of the exercise. While the joint development in itself facilitated the preparation of the students and their active contribution to creating the illustration of the framework, the final flowchart served as a common reference point throughout the course of the exercise. Based on the fact that the flowchart was jointly developed also the students could claim ownership, i.e. they could relate to it more easily as if it was just presented by the teacher. Furthermore, in contrast to previously used work step sequences for individual experimental approaches which were presented isolated from each other and as series of bullet points (see Appendix A), this flowchart allowed to interconnecting the different approaches which were followed in parallel. Also the illustration itself may have a beneficial effect, as individuals may grasp the concept more easily from this than only from text. In addition, the integrated repetitive elements in the implementation plan, i.e. that individual points are discussed and recapitulated (from slightly changing perspectives) several times, are most likely very beneficial to increase the understanding of the students and to internalize the obtained knowledge.

Based on the fact that achieving the primary aims of the exercise which especially includes a basic understanding of methods and results was not a problem in contrast to previous courses, this approach revealed the specific problems students are commonly struggling with. In cases when students are struggling with the basic primary aims of such exercises, these specifically problematic aspects may be covered and not addressed in an appropriate way. During this exercise, in particular two aspects turned out to be challenging for the students: (1) certain pipetting schemes that include the preparation of so called master mixes, and (2) more complex calculations of enzyme activities (despite repeated, relatively detailed instructions). Both points are very specific, but apparently were not limiting the understanding of the overall concepts. In contrast, the overall understanding of the students seemed to be on a higher level than in previous courses. According to the SOLO-taxonomy of understanding (Mørcke & Rump, 2015), they achieved a relational qualitative level which typically was not at all the case in previous courses. This can most likely be related to the structure of the exercise which is centred on the flowchart/whiteboard implementation. Even though some teachers may have reservations to use whiteboards and other “analogue” tools (in our increasingly technological world combined with a possible lack of experience in their use), the positive result of using the whiteboard in this exercise underlines that simple tools can be very useful to improve teaching and support learning. Furthermore, the feedback provided by the students clearly demonstrated their appreciation as it apparently supported their understanding and learning. This seems more important than the use of modern high-tech tools which is in agreement with studies on preferred teaching techniques of natural science and medical students (Novelli & Fernandes, 2007; Waheeda & Murthy, 2015).

The flowchart as the common ground for changing teacher roles

The flowchart also provided a good basis for the teacher to facilitate a supportive interaction with the students. It helped to keep track of the progress of the students, bringing situations very easily back to normal, e.g. when it seemed that time runs short, as no big explanations are needed when referring to an already known scheme. The flowchart was also a good tool for the teacher to shift between different roles (Beck, 2002), e.g. when developing or recapitulating sections of the flowchart at different time-points, either for the purpose of getting back/keeping on track or just to change the scene to diversify the teaching-learning environment. During the exercise itself, i.e. when the students perform their practical work, the teacher’s role varies between a coach (high order of teaching approach, close proximity to the students) for specific tasks and a supervisor (chaos/distance) for the “students’ project” covered by the exercise. When developing the flowchart or referring to it during daily recapitulation and discussions as a common basis, the teacher has the chance to switch to the role of a participant (chaos/proximity) or functions as a moderator which moves the teacher away from the students and increases the order in the teaching approach (Beck, 2002). I experienced this diversified teacher role as a suitable way to adjust the teaching-learning environment in relation to different needs and it seemed also to be beneficial for the resulting understanding of the students.

Outlook

The implementation of a jointly developed flowchart as a central reference point and guide through practical exercises which are spread over several days turned out to be an excellent tool to facilitate student learning as well as to support teaching – at least in this specific case. It is aimed to incorporate this approach also in other similarly structured exercises where appropriate. For this specific exercise, following actions will be undertaken in future courses to optimize the use and value of the already developed flowchart:

1. Requesting specific feedback on the perception and function of the flowchart (including suggestions to improve it) from students
2. Implementing schemes tailored to the specific aspects that turned out to be challenging for the students, i.e. students have to fill out schemes for the critical pipetting steps and calculations which will be collected and discussed in plenum (possibly referring to the flowchart)
3. To facilitate that every participant has to deal with the illustration of the "Expected Results" section of the flowchart, a questionnaire (see Appendix B) will be distributed which the students have to fill out; the results serve as a basis for a joint discussion when developing this section on the whiteboard

Acknowledgement

I am grateful to Katrin Hammer úr Skúoy (University of Copenhagen and Gefion Gymnasium Copenhagen) and Kirsten Jørgensen (University of Copenhagen) for valuable discussions and inspiration planning this project as well as to Vibeke Langer and Frederik V. Christiansen (both University of Copenhagen) for constructive feedback during preparation of the manuscript. I would also like to thank my fellow colleagues of the Universitetspædagogikum course, Annemarie Matthes, Heloisa N. Bordallo, Sumanta K. Das, and Tomasz G. Czekaj for valuable feedback and discussion about the project.

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A

Excerpt of the work flow of a similar course (Basic Methods in Plant Molecular Biology) with in parts comparable content and challenges as in the exercise addressed here.

Experimental Plan:

Approach 1: Identification of wild-type and transgenic plants

Tue: DNA isolation from *Arabidopsis* (wild type and transgenic), gel electrophoresis
Wed: PCR with primers for ITS (ribosomal DNA) und *uidA* (β-glucuronidase), induction by auxin, gel electrophoresis
Thu: GUS staining
Fri: Destaining, evaluation

Approach 2: Cloning of a reporter gene into a standard cloning vector

Sun: Growth of *E. coli* strains with the *pEG640* and *pBluescript* plasmids (supervisor)
Mon: Plasmid isolation, restriction digest, gel electrophoresis, Gel elution
Tue: Gel electrophoresis, ligation, pre-culture DH5α
Wed: Main culture DH5α, preparation competent cells, heat shock transformation
Thu: Visual inspection of the transformation, colony PCR screen
Fri: Gel electrophoresis

Approach 3: Transient transformation of tobacco plants

Sun: *Agrobacterium* pre-culture (supervisor)
Mon: Start main *Agrobacterium* culture
Tue: Infiltration of tobacco leaves
Thu: GUS staining
Fri: Destain, evaluation

B

Questionnaire draft on “Expected Results” intended to be implemented as preparation for developing the respective section in the whiteboard flowchart in dialogue with the students.

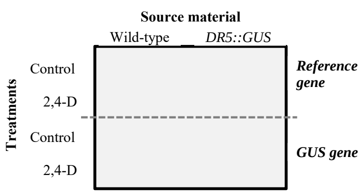
Expected results of the experimental approaches in the laboratory exercise “Tracking Gene Expression”

Dear students,

When performing experiments, it is important to think about results before obtaining them, i.e. which results are expected. This serves as a basis for the discussion and interpretation of the obtained results. As a preparation for later joint discussions of the expected results derived from our work in this exercise, please fill out the schemes below for the three approaches and hand it back to the teacher. Thank you!

Approach 1: Semi-quantitative RT-PCR

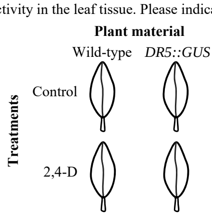
The result of this approach will be DNA bands visualized on an agarose gel. Please indicate the bands you expect to see in the scheme below:



What is the value of this result: ☐ qualitative ☐ quantitative

Approach 2: Histochemical *in situ* GUS staining

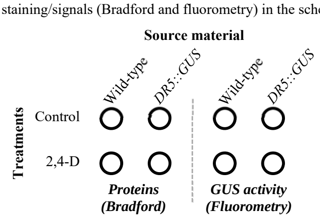
The result of this approach will be blue staining of GUS activity, i.e. the presence GUS is visualized based on its enzymatic activity in the leaf tissue. Please indicate the expected staining in the schematic leaves below:



What is the value of this result: ☐ qualitative ☐ quantitative

Approach 3: Determination of GUS activity in protein extracts

The result of this approach will be obtained by fluorometric determination of GUS activity in protein extracts, i.e. the presence GUS is visualized based on its enzymatic activity which causes a fluorescence signal. An intermediate result will be the content of protein in the extracts, visualized by a blue staining (Bradford). Please indicate the expected staining/signals (Bradford and fluorometry) in the scheme below:



What is the value of the Bradford result: ☐ qualitative ☐ quantitative

What is the value of the fluorometry result: ☐ qualitative ☐ quantitative

5

New students – old sins: elephant in the (lab)room

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Abstract

Laboratory exercises are important in science education as they contribute to general understanding of the topics presented in lectures and enable students to acquire hands-on experience of the scientific research. However, conscious participation in the practical courses allowing for complete achievement of their learning outcomes depends on the proper pre-laboratory preparation. Unfortunately, it is a common problem that students show up under-prepared to participate in the laboratory sessions. This study focuses on medical students, and analyses the level of their pre-laboratory preparation, used techniques, resources and motivational force of the activities. The results show that students do not spend enough time for the preparation and do not use online-based materials. The main reason for under-preparation turns out to be the lack of time. This project discusses also implementation of the possible motivational activities that could enhance the student preparedness and overall performance in the laboratory.

Introduction

Laboratory exercises create learning environment encouraging students to ask questions and helping them to develop critical thinking. There are many specific learning outcomes of practical lab courses such as conceptual understanding of subject, and development of scientific reasoning and laboratory manipulative skills (Hofstein & Lunetta, 2004; Tobin, 1990; Hofstein, Navon, Kipnis, & Mamlok-Naaman, 2005). In addition, laboratory courses carry other important objectives including hypothesis formulation, development of observational skills as well as reporting, presenting and discussing the data collected during practical exercise (Reid & Shah, 2007). Thus, this form of practical teaching complements lectures on a given subject and bridges the theory with applied science research. However, the key prerequisite to a successful achievement of goals and learning outcomes of the laboratory-learning environment is the proper level of preparation expected from the students (Gregory & Di Trapani, 2012). While both the length/workload and the level of the practical courses can vary to a large extend, it is always expected that students will spend time preparing for the exercise. Unfortunately, typically students do not invest enough energy and time into the pre-laboratory preparation that prevents them from full participation in the exercise. As a result, they cannot grasp the aims, follow experimental procedures and comprehend the coherency behind the work design (Gregory & Di Trapani, 2012; Rollnick, Zwane, Staskun, Lotz, & Green, 2001; Pogacnik & Cigic, 2006). This has an obvious detrimental effect on conceptual knowledge development because the cognitive resources are occupied with irrelevant activities, thereby obstructing the learning processes.

The lack of preparation is a commonly observed and described phenomenon seen in many generations of the students, still being an elephant in the room problem; partially avoided, as it is difficult to tackle. Hence, the present project investigates the approach of the students towards preparation for laboratory courses, and presents the analysis and discussion of the data obtained directly from medical bachelors.

Purpose of the study and methodology

The main purpose of this study is to investigate the level of pre-laboratory preparation, used techniques, resources and driving force behind the activities. Moreover, it also seeks to identify potential links between preparation efforts and experimental learning outcomes with the special focus on the implementation of online/virtual resources. The data presented in the study were obtained from a questionnaire consisting of both closed and open-ended questions (Appendix A). The questionnaire was answered anonymously by 30 medical bachelor students (semester 5) participating in the practical exercise conducted during “Kidney and the Urinary Tract” course, held at the Faculty of Health and Medical Sciences in September 2017. The questionnaire was divided into two main sections; the first five questions were retrospective and connected to the previous courses that students held during first four semesters, the last three questions were specifically connected to the preparation for the "Kidney and the Urinary Tract" laboratory course.

Results

First, I was interested in investigating how much time on average students used to spend preparing for laboratory classes held in the first four semesters of their medical study program (Appendix A,Question 1). Figure 5.1 shows the typical amount of time used for preparation for the practical courses using both hard-copy- and online-based materials (Fig.5.1a and b, respectively). It can be seen that 50 % of students spent only 0-30 minutes for pre-laboratory preparation using hard-copy based materials (e.g., laboratory manuals or textbooks; Fig.5.1a). This may imply that some fraction of these respondents shows up for the practical courses completely unprepared. The smallest group of respondents (i.e., only 10 %) were the students who prepared for more than 1 hour (time duration 60-120 minutes), suggesting that long pre-laboratory preparations are not popular among medical students. Strikingly, 100 % of respondents fell in the group that reported to use 0-30 minutes for preparation employing materials available online (Fig.5.1b). Consequently, this could indicate that, due to various reasons, a lot of students do not use virtual-based materials at all. Overall, 10 % of students disagreed strongly that they were always prepared for the laboratory exercises and only 16.7 % considered themselves as being always prepared (Fig.5.2; Appendix A,Question 3).

Subsequently, I investigated the preferred form of preparation for the practical courses (Appendix A,Question 2). All 30 respondents answered that they usually prepare alone (i.e., self-study preparation), indicating that both study-group or other preparation forms are not popular among medical students. When asked for the driving force behind pre-laboratory preparation (Appendix A,Question 4), the vast majority of the students (i.e., 71.4 %) pointed towards willingness to benefit from the laboratory exercises to a maximum possible extend (Fig.5.3). The objective of obtaining the best hands-on experience was the least motivational and reported by mere 8.6 % of medical students. One student was motivated by "other reason" being “to understand what was to happen”. In addition, also the main factor for not preparing was investigated (Appendix A,Question 5). Here, the biggest fraction of respondents (i.e., 70.6 %) attributed the lack of preparation to the lack of time, with lack of motivation or interest being evenly distributed (i.e., 8.8 %; Fig.5.4). As the “other reasons” students gave, e.g., “too difficult laboratory manuals with bad overview of the exercise”, “lack of purpose, often they explain it all in the laboratory” or “lack of previous lectures”.

As mentioned earlier, the three last questions asked concerned exclusively the preparation for the practical part of the “Kidney and the Urinary Tract” course. Here, in line with the previous findings, an average time spent on preparation was analysed (Appendix A,Question 6). The distribution of time duration spent on preparation for this particular laboratory course using hard-copy-based material was very similar as for the courses students held in the first four semesters, with 53.3 % of respondents preparing for 0-30 minutes and only 10 % for 120-240 minutes, respectively (Fig.5.5a). Also, distribution of preparation time based on online material followed the previously observed trend with only 3 out of 30 students (i.e., 10 %) spending 30-60 minutes employing this kind of aids and remaining 90 % of respondents reporting to use 0-30 minutes on a virtual-based preparation approach (Fig.5.5b). The last two questions concerned the helpfulness of both accompanying course lectures and provided laboratory manual in pre-laboratory preparation (Appendix A,Questions 7 and 8, respectively). In general students agreed that the lectures complement well the practical exercise (31 % wholly agreed, 62 % partially agreed; Fig.5.6) and that the laboratory manual is sufficient for the preparation (73.3 % wholly agreed; Fig.5.7).

Discussion

The results presented in this project confirm clearly that the target group, i.e., medical bachelor students enrolled at the Faculty of Health and Medical Sciences, does not spend enough time for pre-laboratory preparation. This is a common phenomenon, observed also in other study programmes, e.g., biological or chemical (Gregory & Di Trapani, 2012; Rollnick et al., 2001; Pogacnik & Cigic, 2006; Reid & Shah, 2007). Moreover, students base the preparation almost exclusively on hard-copy-based materials. From the collected data, it can be assumed that the usage of online-based material is extremely limited. The reasons can be that such tailor-made resources are not being commonly developed and implemented to the teaching at University of Copenhagen, and also that students are not interested, too busy or simply not encouraged to look for the online content themselves. There are a lot of free online sources (e.g., youtube.com) offering videos related to biological, chemical or medical laboratory experiments. Hopefully in the future virtual materials will be much more commonly employed at University of Copenhagen, as this kind of educational aid was shown to be both attractive and helpful in conducting of laboratory exercises (Makransky, Thisgaard, & Gadegaard, 2016; De Jong, Linn, & Zacharia, 2013; Waldrop, 2013). Moreover, such an addition to a hard-copy-based preparation approach may actually ease understanding of the laboratory manuals that are often too complicated or base too much on the previous knowledge causing cognitive overload.

The lack of the pre-laboratory preparation can be associated with the lack of pre-laboratory knowledge execution and lack of consequences for taking the classes unprepared. In the Danish educational system, all students are accepted for the practical exercises (that often are compulsory) without fulfilling any prerequisites. There is no requirement of entry written test, synopsis or oral colloquium/discussion qualifying and allowing the students to enter the lab courses. These forms are successfully used in other countries and are clearly elevating the level of pre-laboratory preparation (Rollnick et al., 2001; Pogacnik & Cigic, 2006; Reid & Shah, 2007). Therefore, it could be worth considering implementing similar strategy at the Faculty of Health and Medical Sciences. Without acting too harsh, one could build on uploading a set of practical course-related questions on Absalon/Canvas to boost the discussion during the laboratory classes and motivate students to make an extra preparation effort or to make students to prepare/read the manual at all. The online pre-laboratory quiz approach was reported to enhance student preparedness and overall performance in the laboratory (Peteroy-Kelly, 2010).

It is evident, that the respondents prepare alone for the practical classes. This is not surprising as each student may need different amount of time to study and, in general, it is more difficult to decide on one common timeslot to prepare in the group, because of busy schedules. The performed analysis revealed that the main motivation for pre-laboratory preparation is to increase understanding in the class. This is uplifting as it indicates that students want to remain conscious during the classes, comprehend and benefit from the content. The most common, yet trivial, factor hindering the respondents from pre-laboratory preparation turned out to be lack of time. This is however rather flippant excuse that could be minimised by forcing students to do any of the above-proposed entry activities.

Analysis of the data related to the “Kidney and the Urinary Tract” laboratory exercise showed that the level of preparation corresponded to the preparation for the practical courses held during the first four semesters, i.e., mostly insufficient. This correlates with my personal perception of the students that attended my classes. Again, online-based resources are not employed in preparation for this particular laboratory exercise. This could be easily improved by, e.g., supplying students with links to videos related to the content of the class. However, the respondents clearly agree that both provided laboratory manual and accompanying lectures are sufficient for the pre-laboratory preparation. Thus, it can be concluded that the low level of preparation is mainly due to lack of willingness/time to prepare, but not due to lack of relevant resources.

Conclusions

The results presented in this study show that medical students do not spend enough time on pre-laboratory preparation, resulting in only partial readiness for the practical classes. Moreover, students do not use online-based resources. Although the best form of preparation would vary from student to student and they master material at their own pace, it seems necessary to implement common motivational activities enhancing the pre-laboratory preparation, e.g., online quiz-based approach. Only well-prepared students can fully benefit from practical procedures designed to have meaningful impact on the understanding of the topics taught during the laboratory classes.

Figures

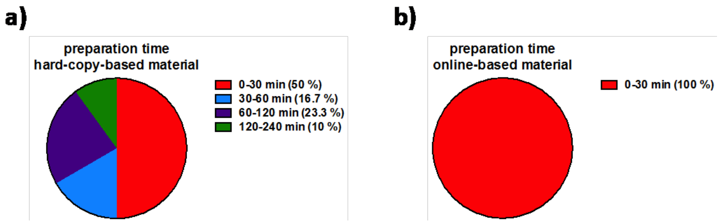

Fig. 5.1: Average preparation time spent by medical students before attending laboratory exercises held during first four semesters of their study program. Pie charts show % of distribution calculated for 30 respondents who selected exactly 1 out of 4 listed time durations (in minutes, min). See Appendix A, (Question 1) for details. a) Preparation time using hard-copy-based material. b) Preparation time using online-based material.

Fig. 5.2: Fraction of students considered themselves as being always prepared for the laboratory exercises. Pie chart shows % of distribution calculated for 30 respondents who selected exactly 1 out of 3 listed answers. See Appendix A, (Question 3) for details.

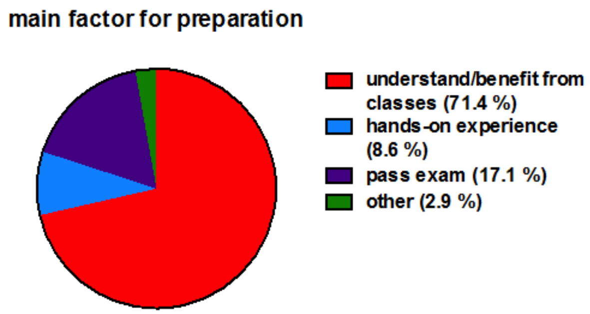

Fig. 5.3: Main factors motivating students to prepare for the laboratory exercises. Pie chart shows % of distribution calculated for 30 respondents who selected at least 1 out of 4 listed answers. See Appendix A, (Question 4) for details.

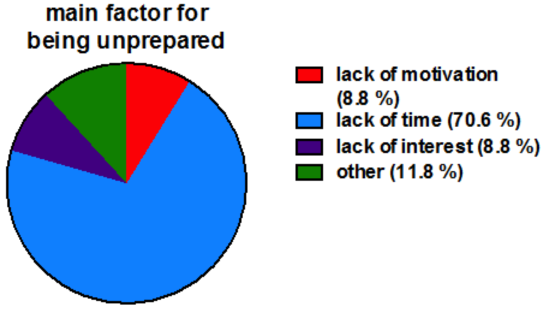

Fig. 5.4: Main factors responsible for lack of the pre-laboratory preparation. Pie chart shows % of distribution calculated for 30 respondents who selected at least 1 out of 4 listed answers. See Appendix A, (Question 5) for details.

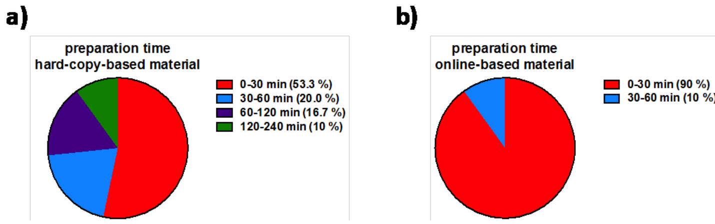

Fig. 5.5: Average preparation time spent by medical students before attending the practical part of "Kidney and the Urinary Tract" course. Pie charts show % of distribution calculated for 30 respondents who selected exactly 1 out of 4 listed time durations (in minutes, min). See Appendix A, (Question 6) for details. a) Preparation time using hard-copy-based material. b) Preparation time using online-based material.

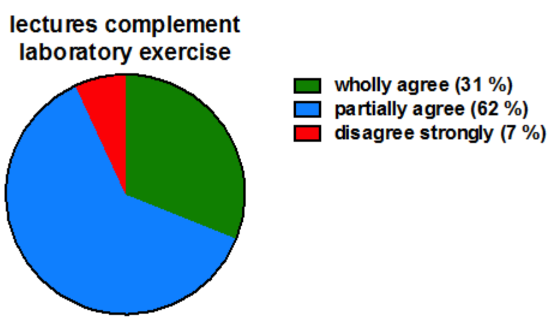

Fig. 5.6: Fraction of students considering lectures of "Kidney and the Urinary Tract" course helpful in preparing for the laboratory exercise. Pie chart shows % of distribution calculated for 30 respondents who selected exactly 1 out of 3 listed answers. See Appendix A, (Question 7) for details.

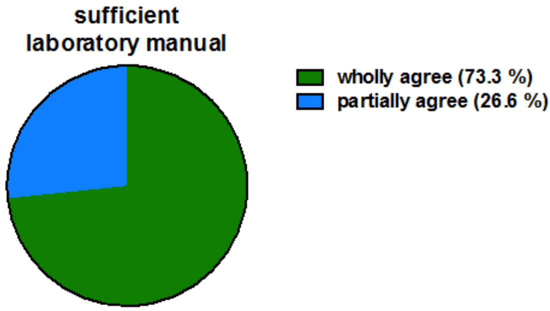

Fig. 5.7: Fraction of students considering laboratory manual of “Kidney and the Urinary Tract” practical course sufficient to prepare for the exercise. Pie chart shows % of distribution calculated for 30 respondents who selected exactly 1 out of 3 listed answers. See Appendix, A, Figure 1 (Question 8) for details.

A The questionnaire used for data collection in the present study

Pre-course preparation for the laboratory courses held in semesters 1-4

1. Previously, how much preparation would you typically complete before attending a laboratory exercise?
   a) hard-copy-based (e.g. reading laboratory manual, textbook)
      0-30 min, 30-60 min, 60-120 min, 120-240 min
   b) online-based (e.g. online course material if available, youtube-related videos)
      0-30 min, 30-60 min, 60-120 min, 120-240 min

2. How do you usually prepare before the laboratory course?
   a) alone (self-study)
   b) in a study group
   c) in other way:____________________

3. I was always prepared for my previous laboratory exercises:
   wholly agree partially agree disagree strongly

4. What was the main factor to prepare firmly for a laboratory exercise?
   a) willingness to understand/benefit from the class as much as possible
   b) getting the best hands-on experience
   c) to pass as the practical exercise was needed to qualify for an exam
   d) other reason:____________________

5. What was the main factor to show up unprepared for a laboratory exercise?
   a) lack of motivation
   b) lack of time
   c) lack of interest
   d) other reason:____________________

Pre-course preparation for the laboratory course in kidney physiology

6. How much time did you spend for preparation for the laboratory exercise in kidney physiology?
   a) hard-copy-based (e.g. reading laboratory manual, textbook)
      0-30 min, 30-60 min, 60-120 min, 120-240 min
   b) online-based (e.g. online course material if available, youtube-related videos)
      0-30 min, 30-60 min, 60-120 min, 120-240 min

7. The accompanying lecture and the laboratory exercise complement each other and help to prepare for the practical course:
   wholly agree partially agree disagree strongly

8. Laboratory manual provided sufficient information to prepare for the exercise:
   wholly agree partially agree disagree strongly

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Part III

Improving supervision

6

How can PhD supervisors help foster independent and critical student work in a multi-cultural setting?

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Introduction and problem statement

In a recent analysis of doctoral students learning process, Odena and Burgess found that *"Supervisors' most helpful feedback appeared to be aimed at helping students learn how to learn by themselves, supporting the development of their critical thinking and writing"* (2017, p. 578). I think this is an interesting finding, and a relevant starting point for questioning how supervisors can help foster independent at critical student work. It has become a key question for my own development as a (PhD) supervisor. Given the university focus on internationalization, I want to explore this with regards to supervision of PhD students who come from more authoritarian academic traditions. This article focuses on the following question:

How can Nordic supervisors help facilitate independent and critical thinking in students from more hierarchical and authoritarian academic traditions?

I will discuss traditions of supervision and supervisor roles, as well as the supervisor-student relations, to address the question. In the paper, I focus on communication as an important element in the relation and place special attention on the use of meta-communication. Furthermore, I will explore the student learning experiences associated with three different types of written feedback: corrective feedback, positive feedback, and feedback as questions, as well as the learning-experiences associated with using visual tools such as diagrams or flowcharts. The purpose is to learn more about how I as a supervisor can support and facilitate learning among students through the use of different types of feedback, but also using other tools. I will highlight dilemmas related to the supervision of PhD students in a multi-cultural setting, as especially the dilemmas contain much food for thought for reflection on own practice, as they exclude easy solutions of 'recipes'. While it would also be relevant to examine the relations and communication between (co-) supervisors around each PhD student, the limitations of space shifts my focus on the communication between the individual Nordic supervisor (as myself) and the PhD students.

The context of this article is within a five-year research program, funded by the Danish Research Council for Development Research, involving collaborative research activities and PhD supervision by two Danish research institutions and universities in Uganda and Tanzania. The program involves four south PhD students inscribed as double-degree students at University of Copenhagen. Each has a total of four to five supervisors between the two universities where they are inscribed. The research project started 1½ years ago, and PhD students have been working for 1 year.

What does literature say about this problem?

Supervision of students from a different academic tradition, and collaboration between co-supervisors ingrained in different academic cultures, requires an awareness of the role and responsibility of a supervisors (and hence, students). As probably many other Nordic supervisors, I I see my supervisory role as a facilitator of student learning processes. Rather than looking for a 'recipe' for good supervision (i.e. supervision that leads to learning in the student), this views supervision as a delicate balance between domination and negligence, in which the supervisor constantly faces dilemmas and new choices (Bastalich, 2017; Delamont, Parry, & Atkinson, 1998; Lee, 2008; Vehviläinen & Löfström, 2016). Inspired by Deuchar's analysis of doctoral supervision styles (Deuchar, 2008) and the idea-historical teaching/learning approaches mentioned by Molly and Kobayashi (2014), I see a coaching approach as being appropriate to facilitate learning, and thereby I orient myself towards what Vehviläinen and Löfström (2016) call the dialogical supervisory culture. The academic culture influences the relation and interactions between supervisor and student (Molly & Kobayashi, 2014).

Analysing international PhD students in a European context, Goode (2007) introduces the concept of dependent and independent learners, which summarizes well the ideals of teaching/learning processes in more hierarchical academic traditions versus Scandinavia. However, Goode points out that the individualization of learning contained in the discourse of the ideal of independent learners, underestimates that **learning** happens **as a collaborative process**. She argues that *"Academic success and failure are neither the property of the individual students nor of the instruction they receive, but lie rather in the relationships between students and the practices in which they and their teachers engage during the course of their ongoing interactions"* (p. 589). Through her study, she shows that the discourse of independence can be an obstacle for international doctoral students[1]. Several authors highlight the need for explicitly addressing expectations between supervisors and students (See for example Andersen and Jensen (2007)). Kobayashi (2014) developed and analysed the use of formally prepared material for discussing expectations. The literature highlights the importance of making explicit the criteria supervisors use for assessing quality. In an international context, this is especially important, as supervisors from different academic cultures may use alternative criteria.

Balterzensen's (2013) review underscores the role of **meta-communication** in supervision. This highlights the importance of paying attention to meta-communication, i.e. communicating about how we communicate, both with regards to having a transparent communication style, but also, at a higher level, regarding the strategic approach to the collaborative learning process. Several authors recommend that supervisors view a needed change in students' approach to learning as a pedagogical challenge to discuss mutually, rather than as a supervisor responsibility (Molly & Kobayashi, 2014; Vehviläinen & Löfström, 2016)[2]. Vehviläinen and Löfström (2016) also found that language, supervision style, feedback styles, and questions influence students' learning and critical thinking, and the study by Odena and Burgess (2017) - mentioned in the introduction - also highlights the importance of communication for the student-supervisor relation, and the changes in this over time. Along the same line, Andersen and Jensen (2007) recommend that (graduate) supervisors become more conscious about the

[1] Following the same line of thought, Grant (2003) proposes that stimulus and support in learning and socializing graduate students should not depend on one or two supervisors, but to a larger degree involve the community of the department.

[2] See Bastalich (2017) for a review of what literature says about different supervision styles and supervision-student relations.

dialogue, conversation and interview techniques used during supervision. Likewise, a recent study found the degree to which supervisors encouraged students to think and act autonomously is associated with greater research self-efficacy in the student (Overall, Deane, & Peterson, 2011), which is an interesting and inspiring finding in the current context of international doctoral supervision.

Feedback is part of the communication that takes place between supervisor and student, with the purpose of creating learning in the student. Lotte Rienecker, Harboe, and Jørgensen (2005) recommend that supervisors prioritize, but limit their comments, especially when giving comments in writing. Following a finding that conversational comments can be used to cover broader and more sensitive elements than written comments, Könings et al. (2016) recommend the use of videoconferences as a supervision tool when students and supervisors are in different locations – again, a relevant finding for international research collaboration and PhD-training.

One of the questions that the abovementioned 'dialoguing or coaching supervision approach' deals with is how feedback and exemplary comments can be given a ways that support a development in the student towards a more independent learner, and a **critical and creative thinker**. The importance of giving specific feedback, also when it is positive, is highlighted by Handal and Lauvås (2005), who also propose that supervisors let the student speak first (for a proposal on a "contract" for interaction, see L. Rienecker, Jørgensen, Dolin, and Ingerslev (2013)). Caffarella and Barnett (2000) found in their study of scientific writing learning processes that a sustained and strong critiquing process, where students (learn to) give and receive useful feedback, is important for the learning process of becoming an academic writer. Yet, in the context of graduate supervision, Lotte Rienecker et al. (2005) warn against feedback that is too text-specific, as such feedback may not include overall comments related to the structuring elements of the work, such as research question, overall argument etc.

Vehviläinen and Löfström (2016) refer to a previous study by Vehviläinen (2009), arguing that feedback is not enough to create independent thinking. Rather, there is also a need for **interactional tools that elicit student views**. Diezmann (2005) uses mind-maps and outline-views as a way of stimulating independent thinking. An interesting study by Brodin (2016) finds that the encouragement of **students' sense of agency** in their design of research and what she calls "pragmatic action" are crucial factors for improving their critical and creative thinking (See also Brodin and Frick (2011)).

Methodology and empirical basis

Based on the above, I designed a semi-structure interview guide, focusing on the individual student's reactions to, and reflections about learning outcomes from three different types of feedback, as well as exposure to more visual tools for thinking and conveying ideas. The reason for the focus on the feedback was, that this gave a concrete and shared frame of reference for the interview and the student's reflection on learning outcomes and reactions to different types of feedback. As such, my interview-guide had four pre-defined themes, which are reflected in the sub-headings in the analysis and discussion section. The interview guide also contained a question regarding moments of intensive learning experiences during the past year. I mainly use the answers from this part of the interviews in the first section of the analysis. Furthermore, many comments about supervisor-student relations emerged out of the interviews about learning outcomes and students' reflections on these, making up a fifth, emergent category in my analysis.

In addition to the individual interviews, performed during four weeks of collaborative fieldwork in Uganda and Tanzania, I also used participant observation regarding field research activities and reflections of the PhDs, including daily team dialogues. In each of the two countries, the research team consisted of two PhD students, two of their south-based supervisors, as well as two of the Danish supervisors. Furthermore, the entire first year of supervision and interaction with the PhD students, via skype, email and during a two-month stay in Denmark, also contributed to the empirical basis for my analysis. I took notes regarding learning processes, interactions, relations and questions posed by the PhDs during our fieldwork, and recorded the interviews and elaborated detailed notes on this basis.

While my empirical data for this article thus comes from a small sample, efforts have been put into the qualitative aspects, with dense note-taking and close personal relations. While no claim of representativeness is made, I argue that the sample of PhD students can be regarded as a 'representatives' of many of the different dilemmas that emerge in the context of multi-cultural PhD supervision, and thus have relevance beyond the specific research programme.

Analysis and discussion

Differences in **academic cultures** can be present in any inter-institutional collaboration, but probably tends to be more distinct and frequent in international collaborations. This can create marked supervisory dilemmas, where meta-communication about the pedagogical challenges can help explain a choice of supervisory role as well allow for a mutual discussion of it with students (and co-supervisors). The differences in academic culture was expressed in one of the interviews, where a PhD student explained that in his country, *"traditionally, the supervisor will say 'do this', and give his input, and add, 'if you do not do this, please do not come back'... "*, indicating that there is not much room for discussion or for the student to find his or her own way forward.

Discussing and clarifying **expectations and challenges** was one way that the Nordic supervisor-team tried to prepare the students for the 'clash' in **supervision culture**, and for their learning of how to learn by themselves. The students' participation in the University of Copenhagen intro-course for new PhDs was part of this. When interviewed about assignments or situations that spurred intensive learning, all mentioned the PhD intro-course, and "becoming owner of their own PhD project" as an eye-opening concept, and something that also changed how they related to supervisors and their own learning process. Nordic supervisors and students have used a checklist developed by S. Kobayashi as a guide for discussing mutual expectations regarding the supervision process and collaboration regarding the PhD process.

Differences in culture and expectations were explicitly addressed in almost every (Nordic) supervisor-student session. Finding the right balance where supervision styles (hands on/hands off) is a good match with student approach and background (dependent vs independent) (see diagram from Gurr (2001) in Deuchar (2008)) is challenging –both from the start of the supervision process, as well as through the progression of the project. For example, one of the dilemmas that I face as supervisor in this situation is that I fear that if I adjust my supervision style towards more hands-on, as especially one of the students requested, I may not lead him towards a more independent learning style - or that it may postpone the progression towards independent learning styles too much.

Realizing that there are large differences in supervision styles between co-supervisors as well as between what students expects and supervisors plan, it is important to be conscious about **meta-communication** – i.e. remember to communicate why we ask a certain question or why we ask interview questions in a certain way, or why wait with probing, explanations, etc. It is also important to ask questions to invite collaborative thinking and reflection, regarding both the fieldwork and the topics we do research on, as well as regarding learning processes and interactions between supervisors and students is important. One way we practiced this during the collaborative fieldwork was to have group reflections every evening about what we had learned - and the implications thereof for the next interviews, for our understanding of our object of study, and our working hypotheses. One of the students mentioned these reflective sessions as one of the moments of intensive learning: *"I learn things [about something] I might have taken for granted... maybe I did not notice, but some colleague may see something - like the woman and her body language that you pointed out - and it makes me reflect and pay attention to new things."*

The student also highlighted another experience from doing fieldwork and reflecting together, as containing intensive learning. Referring to an interview situation where one of his Danish supervisors probed into specific terms used by a local woman in an interview, he explained: *"I felt it as if the skin on my head was being stretched from learning [...] It taught me to listen to the people, what term they use, and still interrogate... Because, you may think you understand, if you do not probe... you go deeper and then you understand differently. It was a moment of wake-up in the fieldwork. This is very important. Validity of information – so much can come out of that small statement."*

However, it is obvious from the interviews that especially one of the students was unfamiliar with the abstraction level and the reflective process it demands to talk about the learning processes and communication itself. Although being a doctoral student, he was unaware about his own learning processes and not even probing or inviting for reflection changed this. This is a huge challenge for the supervisor, as it prevents the development of a common language regarding student learning processes, which is a *sine qua non* for progressive development of knowledge in the student (and supervisor) about how the student can learn by themselves, as formulated by Odena and Burgess (2017). It shows that although the meta-communication and reflective exercises advanced conscious for most of the students about how they learn themselves, it did not have this effect on all.

Learning experiences from different types of feedback and assignments

Because much of the interaction between supervisors and students in the research programme happens via email and comments to electronic texts, I chose to use different types of feedback, given mainly but not only to written texts, as a pre-defined categories in my analysis of learning experiences. The use of assignments including the use of visual tools as diagrams, flowcharts and mind maps were included as a forth pre-defined category. A fifth category was emerging from the interviews and observations, namely the supervisor-student relation.

Positive feedback: Two of the students referred to positive feedback as something important, motivating them and giving them confidence. Both described that they could use the positive feedback beyond the concrete comments, as an example of something that works well, and then try to apply this to other parts of the text. *"It becomes a frame of reference for you, of how to improve the text"*. Positive feedback helped the students because they better knew what to retain in a text. However, the students often revealed a binary thinking, of "right" and "wrongs", and asked supervisors to guide them, in order to not waste time.

Corrective comments: While it is important to spell out why something it not good, it may also be important, to give some suggestions about what it would take to improve the text, at least in the beginning. However, I would often like to hold back with providing concrete solutions, as the PhD students should develop the ability to do themselves, with supervisors facilitating their learning process. Here, metacommunication about why I hold back is important to ensure that the student do not think that it is either out of ignorance or out of lack of engagement. Yet, it caused fear in one of the students when he did not receive specific 'recipes' for improvement. However, even being given increasingly concrete suggestions for improvement, the student did not engage sufficiently in making improvements.

Comments as questions: Some of the students appreciated when comments were given in the form of questions. One student expressed that it *"gives room to think"*[3]. A colleague explained that he preferred comments as questions, because it gives him an opportunity to clarify in case of misunderstandings. Another student saw questions as something that stimulated deeper reflection. However, for the forth student, questions provoked fear. *"I would prefer [...] that you say something so that I least I know this is how I am supposed to be thinking" [...] "If I get open questions, I get puzzled... I get — scared"*. This student was looking to have rules, norms and traditions within the field being mediated to him through the supervisor,

[3] Yet the student added "...I only get frustrated when I read different things that say different things from different authors." Again, I see this as an expression of a desire for things to 'fit' nicely and that literature should agree, which I interpret as being a consequence of an authoritarian academic culture.

rather than having his curiosity stimulated by questions and discussions. This could be understood as an individualized reaction to a cultural clash in academic traditions and supervision-styles (Molly & Kobayashi, 2014). Yet, it poses a dilemma for the supervisor, when some students appreciate a certain supervision style, while another rejects the same style - especially when this supervision style is intimately related to the supervisors' goal of teaching students how to learn by themselves, and be independent and critical thinkers. One the one hand, it may be seen as an expression of an unbalance in the above-mentioned delicate balanced needed between supervision styles and student approaches, in each individual supervisor-student relation. On the other hand, however, it raises a not easily answered question regarding how long to accommodate individual student needs, versus when to draw the line and conclude that a match is not likely to happen, and that a PhD process will therefore be too much of an emotional rollercoaster, with too little coming out of it that meets the Nordic expectations of what a PhD requires.

Using visual tools as diagrams, flowcharts and mind maps: One of the students described the use of diagrams and other visual tools as something that helped him get new ideas and make [his own] sense of things. *"I felt that through the exercise of the flowchart, I made sense of a lot of things, and I got new ideas. [...] It helped me develop my own thoughts on this."* Probing about which resources he drew upon when developing a flowchart, he described it as *"thinking... independent thinking. I get an idea. [...] It is freedom to think out of the box, without just using literature, and then later go to the literature to see whether what you are thinking, what you put in the flowchart, fits with what people write about, and then identify gaps... "*[4]. Another student saw the benefit of visual tools as a good way to summarize. Yet, he also described how making a diagram also helped him get into the driver's seat and find his own position in literature discussions: *"Every author has a different view on variables... and once you get into the sea of literature, because there is so much written... it may be confusing, but then you can start to see which one will help you, with your study, because every author sees elements differently."* Both these experiences seem to confirm

[4] This spurred a talk about the possibility of using visual methods like mind map to map or organize literature into different strands of arguments or line of thoughts, rather than "getting confused" by the fact that literature does not agree... and as a way to move forward from a tradition seeking literature mainly to "confirm" something rather than to discuss and sharpen our critical eye to the elements that make different literature depart from each other.

the suggestion by Diezmann (2005) and Brodin (2016) about the relevance of using visual methods for stimulating independent and creative thinking. Yet, the last student was not able to say anything concretely about what learning and thinking processes, the use of visual or graphical methods had provoked in him, because he was not conscientious about it. My interpretation is that he was caught in a modus of reproduction, not responding to the stimulation within critical and independent thinking, possibly because of the fear produced. This might also be seen as an example of a negative result of a mismatch in supervision style and student approach.

Asking for examples of situations that had caused intense learning, one of the students replied with the **student-supervisor-relation**. *"My supervisor allows me to be able to fall and get up; to find myself. That is the most important thing as a student. Like a baby [whom] is not criticized that she is falling, until she leans to walk by herself. That is how I feel about our relationship [. . .]. Allowing the student to find themselves, their level, is very important, instead of spoon-feeding."*

Another student also highlighted the student-supervisor relation as one of the elements that had been most important in stimulating learning in him: *"The relationship I have with you supervisors; the way we have moved around; I would have been holding back, feared that it might be used against me. . . but I do not feel that way. We learn."* In addition to the relationship in itself, the quote also shows that the interaction in diverse settings, and doing collaborative fieldwork was important for providing opportunities for getting to know each other beyond the more formal interaction in university offices. I see this as an example of the team having succeeded with including the students in inspiring research practices with sound and respectful collegial interactions – and thereby ensuring that the learning becomes a collaborative process (Goode, 2007).

A third student highlighted that for him, an important element in the intensive learning stemmed from the opportunity to discuss freely, even about basic questions. He valued having the freedom to discuss and develop his thinking through the interaction with supervisors during the collaborative fieldwork. According to this student, this was *"not always an option at the university"*. This supports the recommendation by Hemer (2012) that supervisors are conscious about the influence of the context of the supervision, for example by sometimes creating a change from the traditional supervision in the supervisors office, to get out of the supervisors' territory.

Each student highlighted the importance of face-to-face comments, and strongly recommended the use of skype-meeting as follow-up on written comments (by email). The preference of conservation above written exchanges is probably linked to having a stronger personal contact and thus providing a media for communication that fits better with the coaching-supervision tradition, and one where questions are allowed and encouraged. It also fits with the recommendations made by Könings et al. (2016).

Conclusion

A coaching supervision approach aims at facilitating learning processes about how students learn to learn themselves. Metacommunication about learning processes and goals is important when supervising international doctoral students, who come from a more hierarchical academic tradition, for spelling out that independent and critical thinking is an important goal, and that supporting students to learn how to learn by themselves – and therefore also providing them with the space for their own proposals and errors - is an important part of this approach (Baltzersen, 2013; Molly & Kobayashi, 2014; Vehviläinen & Löfström, 2016). A clash in supervision-learning cultures may require that supervisors spend extra time on instruction and reflection with their international doctoral students, as also pointed out by Goode (2007). Supervisors of international doctoral students can benefit from paying attention to language, supervision styles, feedback styles and use of questions that stimulate critical thinking (Andersen & Jensen, 2007; Vehviläinen & Löfström, 2016). Literature (Brodin, 2016; Diezmann, 2005; Odena & Burgess, 2017; Overall et al., 2011; Vehviläinen & Löfström, 2016), as well as the empirical data for this assignment suggests that supervisors (and students) can benefit from giving comments as questions, as it leaves room for students to think for themselves, explain themselves, and find ways forward. Visual methods for communication and thinking about the research also seems stimulate independent thinking by (most of the) the students. However, for some students, feedback or assignments that involve methods that demand independent thinking provoke fear rather than creativity and development of new ideas. For some, the clash of academic cultures and learning styles may become too much of an emotional roller coaster. Therefore, while my research to some extent seem to support the finding by Overall et al. (2011) that the degree to which supervisors encourage students to think and act autonomously is associated with greater self-efficacy in students, I would argue that a modification of the statement is needed, based on my finding that some students reject the [too big?] leap into the uncertainty of learning new competences in new ways.

Metacommunication is essential in creating a common language about the pedagogical challenges that international doctoral supervision poses. Metacommunication about written comments is also important to ensure that these are not treated as text-specific elements to “fix”. However, both literature and empery shows that feedback is not enough to create independent thinking. Other tools, such as the visual tools mentioned above, or interactional tools, are recommended (Brodin & Frick, 2011; Vehviläinen & Löfström, 2016). Encouragement, and the supervisor’s awareness about supporting the students’ sense of agency and ownership, both through communication and through practice, seems important. Yet, it also highlights the supervisory dilemmas faced in international doctoral supervision, where students may face a steeper learning curve, due to their exposure to a still foreign academic tradition. Learning often is accompanied by periods of frustration; and here, the use of metacommunication about overall goals of learning to learn by themselves, as well as the closer and more open student-supervisor relation are important resources to help the student overcome the frustration.

Perspective

During the progression of a PhD project, the challenges that the student and supervisor meet can be expected to change, leading also to changed relationships and different demands on the supervisor and her role, as well as she is likely to face different supervision challenges over time (Benmore, 2016; Boehe, 2016). There is thus a need for supervisors to continuously developing themselves through the supervision process (Halse, 2011), as one “becomes” a supervisor.

Another important aspect in international research collaboration that involves supervision, which has hardly been dealt with here, is the collaboration and communication between co-supervisors, especially when located at different universities, in different supervision cultures.

Finally, supervising students with English as second language (ELS), or coming from academic cultures with little tradition for writing and publishing, poses further challenges, especially when it comes to writing of articles and the dissertation. Odena and Burgess (2017) highlight the need for ESL students in drafting and re-drafting texts, and the influence of the supervisor in developing their writing skills.

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7

Laboratory supervision of MSc projects

Qualitative interviews, thematic analysis, and recommendations for the supervisor

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Introduction

A range of skills can be obtained by students doing a M.Sc. thesis with a laboratory component. By learning in the practical domain the student can gain a deeper understanding through trial and error. Often the laboratory also include working together with other students, PhD's, postdocs, laboratory personal and others on joined projects including development of interpersonally skills within team work, negotiation, planning and collaboration. As a supervisor the laboratory M.Sc. thesis offer opportunities to often interact with the students and provide assistance and feedback personalized and in a timely matter (Wakeling, Green, Naiker, & Panther, 2017). However the evaluation of the student experience in the laboratory as part of the M.Sc. thesis is often limited to the exam (written and oral), which is focused on the scientific topic and not on other skills obtained while in the laboratory or during the student learning experience.

Here I have made qualitative interviews, based on the questions presented in appendix A, of 5 M.Sc. students from the Ice and Climate group to evaluate their experience doing an M.Sc. with a laboratory component in the interdisciplinary field of ice core science. The interviews were analyzed by common themes. The questions covered prior laboratory experience, experience during the thesis, learning outcomes as experienced by the students as well as questions on how supervisors could improve their supervisions. Through a thematic analysis (Braun & Clarke, 2006) of the student responses I suggest how we can improve supervision in the laboratory for coming M.Sc. project students.

Studied group

The 5 students represent the Msc students who were working in the laboratory within the past year; 2 were international (England, Austria) the remainder were Danish. 3 were female. 3 did their MsC program in physics, 1 in Chemistry and health and 1 was part of the international EnvEuro program. The average grade for the students was a 10, reflecting "a very good performance displaying a high level of command of most aspects of the relevant material, with only minor weaknesses". The students are all students who did their thesis within the subject of Continuous Flow Analysis (CFA) of ice cores and who had MsC projects with a significant laboratory component. Thus the laboratory was not only their place for consolidation, but the primary learning environment. In the following the students will be referred to as students S1 through to S5 to ensure anonymity.

Thematic analysis of student answers

The studied group of students is small and while this may limit the validity of the results to a larger student base still the thematic analysis (Braun & Clarke, 2006) and categorizing of student answers has common directions. Based on the student interviews suggestions on how to improve supervision for Msc doing a laboratory based thesis is presented below.

Expectations and relating to prior laboratory work experience

Most students have only limited experience with both the specifics of the CFA laboratory and with ice cores in general. They come from a variety of study (and cultural) background making it a challenge to modify generic Msc project descriptions advertised online to suit the individual students. Our general approach is to interview the students prior to starting the thesis about their skills in statistics, programming and laboratory work and we try to let them know what to expect from doing a thesis with a laboratory component, yet several of the students answered that they did not know what to expect when going into the laboratory. Surprisingly the interviews also revealed that especially **the foreign students had no (!) prior experience**

in the laboratory and the Danish students did not connect experiences from previous laboratory work to this one:

- (I) did not really know what to expect. The only lab work I had done prior to CFA was the mandatory lab exercises in mechanics, electrodynamics and quantum mechanics. I expected these to be quite different from CFA which they were .-Danish student
- I did not have prior experience with laboratory work.-International student
- I had previously only worked on design projects or short term lab projects all combined only 10 days or less in the lab-International student

This suggest that a more thorough introduction to general conditions of working in an experimental laboratory is needed. The supervisor should **relate the "new" laboratory to students previous student laboratory experiences** if such exist (eg. laboratory notebooks, protocols, keeping lab clean). With the advantage that this could improve student self-esteem by making the laboratory seem more familiar.

For all students **the professional research experience was important and motivating factor.** The students expected and to some extend were motivated to learn how to work in a professional environment and were intrigued by seeing the process from start to end, one student was also very motivated by working independently within a project. Most our students work on "real" projects that are valuable to our scientific society. The students know this and are motivated by this especially in the beginning. Similar motivation increase among students, when the purpose of being in the laboratory is clear has been observed in other studies (Russell & Weaver, 2008).

- I did expect to learn a lot and specially how to act in a professional lab.-S3
- I was interested going to the laboratory in order to gain knowledge about where the data actually comes from. So I expected to gain knowledge about the continuous flow measurement system, the single measurements, how to interpret the graphs, the interaction between the different measurements and also how to identify faulty data-S2.

First experiences in the laboratory-The apprenticeship

The first day in the laboratory we mostly instruct the students how to do things, they are normally brought in as an extra set of hands and thus do not fill a specific position in the laboratory the first time they are there. We purposely **aim at making the initial supervision an apprenticeship** (Rienecker, Jørgensen, Dolin, & Ingerslev, 2015) based one, giving the students simple, yet important, tasks to ensure success or have them observe how the rest of us behave around the laboratory, while explaining our reasoning for behaving in a particular way with the aim of osmosis. This is well reflected in the student's description of the experience, it makes them feel comfortable meeting the new place to have thorough instructions and they are further happy that they quickly get something "real" to do.

- In the beginning, I was always assisted while working with chemicals both making sure that I had everything I needed, learned how to use things like pipettes etc. and to make sure that I felt confident repeating it on my own later on. I felt really comfortable with the supervision in the beginning-S4

However, especially the students from outside of geophysics Msc programs (eg. international students) describe it as a **challenge to get introduced to something completely new** and meeting a new environment. Also the actual acquire of new skills was described as challenging, but **learning new skills were also described as motivating.**

- The first challenges I faced was to be put into a new environment, but I was warmly welcomed at the lab and felt very comfortable from the first day.... I wanted to achieve all steps required by myself. So it was a mixture of being stressed and having positive feelings about new achievements. The achievements were motivating.-S2
- I remember feeling quite stupid and somewhat ashamed -since it was my first day doing actual lab work, but no one commented on my mistake as a failure or with negative comments. It was mostly a feeling I had myself, and it was hard to admit to others, so I didn't verbalize it-S5

As a supervisor, especially when the student is new to the subject, it is important to accommodate the challenge the students face meeting a new environment. Relating to students previous experiences, praising them with the fact that they are engaging in this new experience, putting them to work at simple tasks that they can complete easily but which still has purpose, vocalizing that this is a new experience for them and that it is natural that they have questions and asking them what surprises them are all tools that the supervisor can use to engage the students in the new environment (chapter 1.2).

Progressive learning (From apprenticeship to partnership)

All the students experience a difference from the supervision taking place in the beginning to the one received toward the end. They experience a **move from apprenticeship to partnership** and appreciate this move. This reflects that while the students ask for a better measure of their progression during the thesis, they all at the end **feel they have progressed significantly to a level where they are partners and fellow researchers rather than students.**

- My goals changed more times after I became new insights and ideas from you throughout the process. I felt that I always have somebody to ask if I don't know further-S2
- I was always supervised when doing new things in the beginning, which has really taught me a lot on how to work in the laboratory. After I started to feel confident on my own in the laboratory, I had my freedom to work independently on my projects well aware that I could always ask for help or supervision. I found this very motivating and I have never had the feeling of being left alone with tasks.-S4
- At first I was the new girl, and I slowly progressed to be a more experienced member of the group as I participated in multiple melting campaigns and worked with my own lab instrument. I would help teach other new msc. Students about the rules and methods of the lab and cold room, which gave me an even better understanding of the lab work and which made me feel assured of my place in the group and sure of the science-S5

Students motivation

The students describe a variety of things that motivated them. Just being in the laboratory doing the same as "real scientist" was one;

- I wanted to experience how it would be like to work in lab for a longer term and see the process end to end.-S2

- I quickly got to be part of the routines, doing a lot of the same things as more experienced people did. That was a really nice experience and made me want to learn more and do more things.-S3

Being part of generating real ice core data and doing a valuable job was also motivating for all the students. They further want even more work on generating and working with “real” ice core data.

- The laboratory was motivating because it was exciting to melt ice cores and watch the data first hand.... I find it motivating to gain knowledge about what I do and what for I am doing it.-S2
- I had few expectation of the group work, the methods and the science itself as I was new to the field, but I was very excited to know that I would be working with ice and analyzing it for proxies of past climates, which I think is pretty badass-S5

Having a thesis with a variety of assignments also was motivating for the student and the fact that the laboratory is part of the thesis work is a motivating factor for all our students:

- it’s nice to be able to do somethings practical and not just sit in front of a computer all day. Being able to go down in lab and work with your hands and do some experiments is important for me. Only sitting at my desk would decrease my productivity greatly.-S3
- I personally like to build and develop things and therefore the CFA laboratory provided me with all the academic and practical challenges and motivation I wished for.-S4
- The practical lab component was in my case very motivating as it was a new development and I was allowed to be creative in my design process which suits me and which I’m good at –S5

Being part of a group

The main motivation for the students however was the social aspect, interaction with other students, and other people (real scientist) in the laboratory, and all students have stressed this as an important part of their Msc experience. Research suggest that students **opportunities for meeting others outside formalized sessions is crucial for their learning**, eg to network and debate (Rienecker et al., 2015), and there is also evidence that if students find themselves to be an integrated part of a research environment, they perform better (Rienecker et al., 2015). The **students coming from other than geophysics Msc programs stress that they liked or wished that they had joined a group of other students**. This reflects that the subject is on the edge of their study program and thus they benefit from other peers to reflect on their thoughts of the laboratory work. These students also ask for more pointers as to where they are during the progress.

- It was nice having other master student there, so that way I was not the only one with little/no CFA experience because this made it a bit more comfortable ....(I would advice...) to have maybe 1-2 students with similar experience level because this allowed for sort of mutual learning and idea sharing -S1
- Maybe make a buddy system where the "stupid" questions can be asked between students msc., phd, bach even?, or a monthly discussion session with similar content – this could be arranged across groups at CIC (Center for Ice and Climate, red)-S5

On the contrary the geophysics students are mostly motivated by working independently:

- I like to work independently, knowing that I always can ask for help if I need it. It has therefore been a great motivation for me that I had my freedom to do this within this group, both for settings things up and testing my setup in all thinkable ways. –S4

The **students experience that being part of a laboratory group working with multiple people at different academic levels have been beneficial for their project**, but also complain that sometimes they are not properly introduced to other people working in the laboratory hindering such a positive interaction. Thus the supervisor should be aware that the student may not (especially initially) have the confidence to introduce themselves in an academic setting and thus the supervisor should be the initiator of contact between students and others in the laboratory.

- Even though I didn't have any experience within this field, I felt quite comfortable working on my own in the lab because I always could ask others in the group for help/advice.-S4
- The laboratory was motivating because I had the privilege to be in a team-S2
- Maybe a better introduction to others who will be in the lab at the same time, even people from other teams such as the gas team, so that they

know who the student is and why they are there ....of course they did soon anyway, but a more clear initial introduction... maybe?-S1

The students in the CFA group take part in weekly meetings where they can present and discuss their laboratory work. These are held very informal over coffee and everyone is encouraged to present where they are at with their own project. Such meetings are useful for student progress and motivation and Dunne (2014), who introduced such feedback sessions within a course having a laboratory component, our students also find them useful. In the study by Dunne (2014), 74% of students indicated that this sort of feedback session was useful. Stevens et al. (2016) evaluated how using a specific joined group project to teach and transfer good scientific practices for PhD students could be beneficial, and found that **"that this process was clearly beneficial to students in helping them to become a strong cohort who learn from each other and are more confident in their research."** . It seems the combination of face time, the option to ask both peers and supervisor and get direct feedback on some particular part of the project was received also very positive by the students, who explain both the benefit of the specific project and for them feeling they belong in the group. The group meetings were appreciated equally by the more independent students.

- Another very motivation for me was the weekly CFA meetings where you could present your results from tests in the lab and both professors, Postdocs, PhDs and other students could discuss your results, your approach, problems etc. and provide you with new knowledge and new ideas for future tests. This is off course a very convenient way to get a better academic understanding of your project but it also made me feel like a part of the research group on an equal footing with the others-S4.
- (working on something useful for the group, red) and it made me feel like I contributed to the whole group's work and expertise by designing this new instrument-S5

However the students express **the wish for even more group interaction and peer-feedback** and they themselves suggest even more student presentations for the scientific group.

- make us present the lab and the data-results for someone else, so that the we also can feel and understand how much we've learned during the thesis process-S5

While this oral style of presenting own material may be great for student learning this is time consuming as only one student would get feedback. To save supervisor time it may be better to rather use **student peers and to arrange small presentations between students**. The students are already expected to present results and discuss them at the weekly CFA meetings, however it may be that this **expectation should be more directed to specific students so that they know to prepare and present material** during weekly meetings. Journal clubs as suggested by the student below is another way to facilitate good practices, they serve the purpose of keeping up with the literature, they can be used to teach the forms of sharing and evaluation of scientific findings and students learn the written conventions for presenting science by reading articles and seeing what is well received (Golde, 2007).

- Maybe set up a journal club within the group, to make the students learn how to be critical of papers relating to the lab equipment, methods or results. I did an initial review of a paper for my supervisor, we then discussed it and I learned LOADS from that one hour session: How to review a paper, how to review my own work (!), how to relate the paper's results to the group's and the lab's and it made me think how I could design other experiments, setups and instruments to test if the paper's hypothesis was right-S5

Further **journal clubs** rehearse student dissemination skills used in the final thesis presentation. Such journal clubs could be set up to work between the students without much supervisor time spend, besides the facilitation and booking of space, however including PhD's and postdocs would serve to check that the Msc students do obtain the necessary knowledge from the articles. Many of our students read the same articles describing equipment and background ice core research and over the course of a year one with journal club once a month or every two weeks the students could go through those relevant to all. However some initial pointers as to what to obtain from the articles may be necessary from the supervisor.

Another option is to ensure that Msc students have a **student buddy**, who is also doing a Msc project with a laboratory component. Ideally the buddy would be a few months ahead of the Msc they are buddy for. This buddy could act in multiple ways, having been already part of the group for a few months, they would be able to answer practical questions on how/where to find things in the laboratory, who to ask, what kind of official regulations/forms are required when doing an Msc, give feedback on initial written text etc. The problem with this format is that we only have limited number of students and also that not all students are capable in providing feedback to other students in a good way. Some sort of “contract” explaining the conditions of being buddy should be used if we choose to implement this strategy. Dependent on the academic level of the two students involved and especially of an imbalance in this it could also cause more uncertainty and anxiety between the students.

As a student supervisor of projects in the laboratory one can take advantage of knowing the students initial motivation for the project. Students are bound to face challenges and variation in the amount of motivation, while doing a thesis lasting between half a year and 1 year. **However if the supervisor is aware of the student motivation, they can easier connect to the student by referring back to the initial motivation in times where the student is feeling challenged**. Thus interviewing the students thoroughly on their initial motivation can be valuable for motivating them later in the thesis process.

Student supervisor relations

While the research group is important for motivation, the students also stress the importance of time with the supervisor. They even **would like more time with the main supervisor**. Further they stress the **importance tailoring the supervision to the individual need of the student.**

- It is important that there is a good communication between the supervisor and student throughout the entire project so both parts know exactly how much supervision is needed for the individual student . . . both in and outside the laboratory- S4
- My other classes were badly timed, so I had almost no time in the lab together with my supervisor. Even though I was excellently supervised by others (Phds and professor, red) I would still recommend to allow the student more time with the (main, red) supervisor-S2

The students all **stress the importance of time with the main supervisor. Thus meta-communication regarding the supervision (and sometimes the lack of supervision) is key**. At the moment we do not have any written communication regarding the nature of the supervision, but spend some time prior to the students starting their project to discuss the mutual expectations. We as supervisors in the CFA group often make use of co-supervisors, because we are often absent in longer periods due to teaching, travel or other obligations. Co-supervisors are PhD’s and/or Postdocs. However it seems that the students do not recall or do not experience that supervision having similar value. Thus negotiating expectations by the beginning of the thesis by **making a written *Memorandum of understanding*** (Rienecker et al., 2015) could be useful. Further **written student-supervisor agreement**, stressing to the Msc that they are being supervised in a team may make the lack of direct time with supervisor not as an issue of neglect to the student, which is how it is currently experienced by some. Actually several students' address the lack of time with supervisor at different stages of the thesis process. Reflecting the fact that supervision time is often a limited resource due to other supervisor obligations.

It is hard to find more time for one on one supervision, we could seek to improve this feeling of lack of supervision by other means. The students generally wish for more time and more introduction with the supervisor. Again meta-communicating about the lack of time that can be spend on supervision could help the students accept the situation instead of stressing about it and introducing a buddy system or making it very clear who is to ask for supervision when the main supervisor is absent would give the students a clear place to turn. Another mean is to have the students be part of a group supervision. This is already done and the student experiences are described above. Other solutions to the students wanting more supervision, but the supervisor not being able to provide that due to other constraints could be to make it even clearer that the students can always ask, but also that it is the student own responsibility to ask when they need guidance. **The students have generally not expressed the need for more supervision during the thesis progress** and of cause many reasons for this may exist one being the uneven relationship that naturally is between student and supervisor or that the student simply did not realize they needed guidance until after the thesis submission. As a supervisor it is crucial to be aware that student silence does not necessarily mean that the student is progressing as expected. Some students also were keen to get a **better idea of their progression during the thesis wor**k. Keeping better track of the progress could be beneficial for both student and supervisor. The students themselves suggest

- Maybe make a progression sheet with more fixed deadlines so the student knows what is expected and the supervisor will remember as well?–S5
- Maybe some mini deadlines... knowledge showing points while doing the lab work would help more, although not so much that it is hand holding. It was nice to be able to have my own schedules but maybe one mini deadline, or presentation on what the student has learned,

> once a month or something like this could also be helpful for learning. We had the mid-way review and that was good, maybe also a quarter way and ¾ way review?-S1

Such progression monitoring is currently only done by the weekly meetings. However doing the weekly updates in a group can also hinder the students stating that they are truly lost or need help in fear of losing status. Progression monitoring could be done by **keeping small log-files written by the student** or as suggested by de Kleijn, Meijer, Brekelmans, and Pilot (2015) a log made by the supervisor could even increase supervisors' consciousness concerning their own supervision practices, as well as help the supervisor adapt to the specific need of the individual student. The log for supervisor used in the de Kleijn et al. (2015) study included the following questions.

1. Based on what student signs did you decide on what strategy to use in the supervision meeting?
2. To what extent are you satisfied with your role in the supervision meeting?
3. About what specific aspects of the meeting are you satisfied and/or dissatisfied?

While such a supervisor log is definitely a great idea for the supervisor to improve, it does not solve the main problem, which is lack of one on one time. Further when supervising laboratory Msc's often the supervision is done on the fly in the laboratory and thus rather than having a specific time set aside for supervision with the potential of reflecting on this afterwards. Using supervisor self- reflection logs as a laboratory supervisor would require the supervisor to set time aside by the end of a busy laboratory day, and being able to remember specific supervisor student interactions long after they have occurred, neither is always possible, though likely would be beneficial.

Summary of suggestions for the supervisor

Based on the outcome of the interviews and the following thematic analysis I suggest the following improvements on supervision of MSc students working in the laboratory.

- **Be aware of student differences**. Tailor supervision to the individual student. Students coming from other than geophysics Msc programs stress that they liked or wished that they to a larger degree had joined a group of other students, while the geophysics students were motivated by working independently. Foreign students had no (!) prior experience in the laboratory and the Danish students did not connect experiences from previous laboratory work to this one, help the students relate to their previous student laboratory experiences
- **Move from apprenticeship to partnership**. Make the initial supervision an apprenticeship, the students feel challenged by getting introduced to new items in the laboratory, but motivated when successfully acquiring new competencies. But later move from apprenticeship to partnership. The students like to move to a level where they are partners and fellow researchers rather than students
- **Make student part of a group**. Introduce the students to (all) other people in the laboratory environment. Opportunities for meeting others outside formalized sessions is crucial for their learning. The students experience that being part of a laboratory group working with multiple people at different academic levels have been very beneficial for their project. It creates students who learn from each other and are more confident in their research. Further the professional research experience was important and motivating factor, relate the student thesis to the scientific field and current research in the larger group too.
- **Ensure feedback**. The students wish for more feedback, consider as a supervisor how you can facilitate even more student group interaction and peer-feedback, eg by arranging small presentations between students, journal clubs and or creating a student buddy system.
- **Meta communicate about expectations and limits**. Have time for the students and if you don't metacommunication about your lack of time. Be direct about your expectations during group meetings so that students know the expectations you have for them and the purpose of the meetings.
- **Write it down**. Consider making written *memorandum of understanding* and/or a written student-supervisor agreement. This way both student and supervisor can remember how much time was planned for supervisor interaction and it is clear which other people can act as co-supervisors in your absence etc. Consider having the students write small log-files on progress and as a supervisor logs reflecting on your own supervision practices can increase your ability to supervise.

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A

Interview guide

The students were interviewed based on the following questions.

1) **Describe your expectations prior to working in the laboratory**
eg. Why were you interested in going to the laboratory? What were your expectations? why? Did you have prior experience with laboratory work, which? Why did you choose this thesis?

2) **Describe your first day(s) in the laboratory**
eg. Which challenges did you meet? What was motivating, what was discouraging? How did you feel?

3) Describe your overall experience doing a thesis with a laboratory component
eg. Which challenges did you meet when doing a thesis with a laboratory component? What was great about doing a thesis with a laboratory component? In what way (if any) was the laboratory component motivating? How did you feel during your thesis process? why? Did your goals or motivations change during the thesis? What did you learn? How was/is that useful to you now?

4) **Describe how you experience(d) your role in the laboratory?**
eg. In relation to your supervisor? In relation to other students? Did it change over time?

5) What 3 advice(s) would you give your supervisor to make for a better experience in the lab for the coming students?

6) What 3 advice(s) would you give your supervisor to make for better learning outcome in the lab for the coming students?

7) What 3 things would you suggest your supervisor stop doing to make for a better experience in the lab for the coming students?

8

Students' supervision and introduction during the initial period in the research laboratory: does it matter?

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Summary

This project reflects on my own experiences and development period covering the last three years of Master student introduction to and supervision at the Department of Biomedical Sciences at UCPH. It consists of Problem statement, questionnaire design covering introduction and the follow up with students, analysis of responses and a discussion of the results and possible adjustments in order to improve the initial period of integration to a new professional environment.

Introduction and problem statement

My project concerns evaluation of the very first steps of introducing new Master students to the working environment of the research laboratory. Typically, those students spend ten months working in the laboratory to generate scientific data and write up their master thesis project. However this ten months are actually the first time (in most cases) where students are working in the professional environment directly linked to their study subjects and thus represent their first 'real' job, the first time where they can evaluate their aspirations, plans and directions they set up themselves for by selecting a given study profile at the university. This in turn gives an importance to the initial introduction and early follow up of those students in the new laboratory setting. The way they are welcomed and placed within the working group, the way they are supported, mentored and navigate may be critical for their decisions impacting career paths and jobs they will decide to undertake after the completion of this period.

Much emphasis has been put on a classical teaching which I understand here as lectures or classroom teaching. However, my daily responsibilities and functions as a young teacher-researcher are, as mentioned before, defined by the supervision of Bachelor, Master and PhD students. Within that supervision, important phases can be defined as: introduction to the new environment and responsibilities, settlement where the most of the project related activities occur and closing where writing up the project and defending it takes place. Introduction to a well-functioning, close-knit group can be difficult particularly for people with limited experience working in professional environments. It can be compared to a stressful situation where one was getting a job without required qualifications to fulfill it. Nevertheless, codified procedures of such introductions and early follow-ups are scarce within universities and relay mostly on person-to-person interactions between the student and its daily supervisor. The existing procedures focus on providing optimal feedback mostly in the context of professional growth: experimental design, practical advice, data analysis and ability to write and present the results. They leave open the more 'wholesome' approach to a student that undergoes critical transformation into professional life.

Our own laboratory has prepared a general 'admission file' which we use during our students introduction. This is given to students and discussed with them during the first meeting. However, it contains mainly practical information covering laboratory and safety rules, necessary steps to be taken to integrate to the work place like access cards, email set up, working station and office space. This document is not backed by more descriptive one, normally to be used by supervisors, that would touch on students expectations, professional plans or even personal limitations that may be vital during the initial transition period. My discussions with peer supervisors from Panum Institute describe very similar situation in all the laboratories, with some having no formal introduction to the new work place at all.

With this particular focus and approach, I believe this pedagogy project can contribute to the overall debate on the importance of the way we introduce young people to the new environment and extent of the support we, as supervisors, offer for them in their final stages of academic education.

Hypothesis

I hypothesize that well organized introduction and critical subsequent follow up within the first 1-2 months of a student project has a positive impact on:

1. Life altering choices (future career planning)
2. Performance within the project

Objective

The main objective of this pedagogy project is to assess students' early experiences within the new working environment in order to draw relevant lessons and point out limitations and possible adjustments to the processes covering initial time in a new working environment.

Methodology

A group of students that have spent at least 6 months of their studies working on the research project in the laboratory of Immunoendocrinology Section at the Department of Biomedical Sciences was asked to respond to a questionnaire concerning their supervision, introduction and follow up during their respective research projects. The students were asked to answer Yes or No and possibly provide more expanded comment on their answers. Six our former students participated in the project.

Results

This section will give an overview of provided answers. A total of 6 students were asked to fill in the questionnaire and all responded. The following questions were asked:

1. Do you think that the way in which new students are introduced into the research laboratory is important for them and research group?

All students responded Yes to the question. This may not be surprising as it follows a general expectation that a good introduction represents a 'good first impression' generated between two people or groups of people and is somewhat representative for a broader cultural background (Carlston, 2013). However, it exemplifies also a recognized need for help in transitioning to, in most cases, a completely alien milieu. Almost all students responded along similar lines: *'Because it is always important to feel welcomed so you can have a great start.'*, *'Because it makes it clear for everybody what is expected to be done'*, *'Because it is very important to teach new students good manners and habits in the lab','It's important both socially (get to know lab members = good working atmosphere'*, *'Because first impressions are very important'* and *'The right introduction also makes for good socializing where you e.g. can enjoy lunch together, making the workplace more enjoyable and fun for everyone'*.

However, they also recognized other important aspects of the impact, that introduction can have. That covers their adaptation to new responsibilities towards a new working environment, clearly indicating that they recognize their own professional responsibilities. Good introduction *'is also an advantage for the research team, because the newcomer faster becomes an asset rather than a liability'*, is important *'scientifically (good intro to the lab and techniques = higher quality of output, less risk of mistakes, contaminations and accidents)'*.

Interestingly, students, although only two of them, recognized that the way they are introduced can impact their own professional future *'because in many cases it is an undergraduate student's first research experience so it helps them to reduce stress and tension as well as become familiar with lab routine, procedure, etc.'*and *'it will serve both the student and the lab many fold in the long run'*.

All three covered areas point to student expectations and good understanding that this is their first and important step towards becoming a professional work force. They are open, eager and clearly expect a warm and precise introduction. For them the whole world is changing, new opportunities are present and they want to use and contribute to them.

2. Do you think that such an introduction can have an impact for the future career planning?

Here, again, all students agreed and answered Yes. Derived from the first question, it gave students an opportunity to elaborate more about the future consequences of the way their first *'job'* started and modulated their attitudes. The majority of answers was similar to the following one: *'It can determine someone's view on the field – positive or negative'* and *'it could easily shape their attitude and what to expect from a career in research and how research can vary'*.

They also recognized the broader importance of a good working environment by stating: *'If you do not have anyone to talk to in the place you have to go every single day, you will not stay for long, even if they have the perfect job for you with the perfect salary'* and an impact it may have on their own path: *'it is a great way to get people more involved and more interested in a future career'*.

3. Do you think that such an introduction can have an impact on your yearlong project success?

With this question it was possible to asses a more direct role of an introduction on the students' project itself. Do they think that they can cope for some time with a not perfect work place and still succeed in their master project, apart from the impact on much longer professional choices? Much shorter perspective brought a slightly divergent opinion. While some of the students, probably coming off the first two questions, still strongly valued good introduction: *'I think introduction will bring you closer to your goals and makes many things clear as well as make you interested in the field of research.'*,*'Since efficient approaches in our line of work are essential for experiment execution and ultimately project completion I think it is extremely important.'* and *'A good introduction may help eliminate (sometimes silly) mistakes and accidents, which can lead to better quality research in a shorter amount of time, others felt much more secure about their ability to complete their tasks independently of the conditions: 'A year is long enough time to figure things out even without a proper introduction'*. Possible interpretation of such answers may lay in the fact that we tend to expect a positive conclusion of our short term tasks (self-enhancement (Ferris, Johnson, & Sedikides, 2017)) as they represent something we can easily envision and thus gives us an impression of stronger dependence to our own aptitudes.

4. What do you remember from your own introduction to the Immunoendocrinology Lab?

I wanted to analyze the quality of introduction into our laboratory of its new members and see if their opinions (good or bad) correlate with their decisions to follow a PhD program or other professional choices.

All students indicated that the introduction process was good and friendly: *'I remember everyone being very welcoming towards me. I remember feeling part of a group very fast, given responsibility, people caring and listing to what I had to say.'* and *'I was welcomed warmly in the group.'* Importantly, practical elements of introduction were also well taken care of: I got *'a list of stuff to remember to do or where things can be found, because it is very easy to forget when you get a lot of information at once.'*, *'It was a great feeling that the head of department walk with me around the lab and show the devices, instruments, guidelines etc. I had a doubt about choosing the project but with his introduction I had a feeling that "I can stay for certain" and 'I was given increasing responsibility throughout my project progression, I was taught multiple biological and biochemical methods, and allowed time and space to try to combat any issues on my own. A valuable lesson. I was giving the tools to resolve problems.'* Additionally, students were assured that this is a learning period, that they will encounter difficulties and make errors but they will be supported at every step. The goal was set up clearly, to learn, get better, write a good thesis and be more prepared for the next professional steps, whatever they will be for them: *'I was told: "you will make mistakes, break stuff, and ruin long and expensive experiments. But that's ok. Don't panic. We are all here to learn." For me, that was the best thing to hear because it removed all the stress and anxiety of working in the lab. Also, "the mistakes are not mistakes if you can learn from them" put things in a different perspective.'*

The introduction in the Immunoendocrinology Lab has been developed over the years from scratch. With every new student we aimed at improving it through collecting students' feedback early on as well as at the completion of their project. In the beginning we decided that there are certain general aspects that each student needs to be taught but at the same time we always remember that the approach has to be individualized. That it needs to take into account students background (many of them are not Danish and no one was originally born on Copenhagen), their possible limitations (often they have additional jobs) and critically their post-Master thesis plans. Students were always asked about the PhD plans and informed that if they decide so, and with consultation with us (professor and assistant professor) we would set up plans for writing up PhD applications. In case they did not plan to follow academic career we would modify they project so that they can learn techniques and approaches suitable for their professional choices (most often pharmaceutical companies). At the same time we made sure students will meet all the Master thesis expectations put by the University. Majority of them defended their thesis with a mark of 12.

5. Do you think that a subsequent follow up meetings play an important role in adjusting your expectations and specifying future plans?

Introduction is a first step. Then reality settles and first follow up meetings are focused on helping students not only adjust better but to answer new questions they may have after spending about a month in the lab. And not surprisingly, all students responded Yes providing following extended answers: *'MSc students might have an idea for future plans at the beginning but in most cases it changes along the way, when they get familiar with independent lab work'*, *'I think it is important for the student to have follow up meetings to adjust these things as it, very commonly in science, goes a different way that you thought in the beginning.'* and *'many questions do not pop into your head until after the (first) meeting is over, so it is nice to have a second one where you can ask those questions.'*

Three out of six students saw value in follow up meetings in the context of a longer perspective. They understood that first weeks in the lab could have been critical for them, or have been (*'Because time offers perspective'* and *'it is possible to evaluate weakness and strengths'*) and thus wanted specific information *'whether there is a possibility of continuation of the project in question'* as a PhD or if similar projects can be found outside of academia. They evidently developed a much more precise expectations and gain insights into what can come next when they finish their current assignment. At the same time, as more informed individuals, they welcomed another discussion about the projects and consequences of the decisions they were making.

The two following questions attempted to put in the perspective (from previous questions) the students plans and their outcomes.

6. Did you want to become PhD student after your MSc?

Four students indicated their interest in following a PhD path while two decided to look for the job outside of academia, even before the Master project initiation. In the follow up question:

7. Did you become PhD student after your MS?

Two students started their PhD while four others not. Two, currently PhD students, provided follow up explanations: *'Because it is a great way to stay in cutting-edge research in the lab. Also I was very happy with the* *group members as well as my master's project.'* and *'I like how research is ever changing, plus the freedom to pursue research ideas in academia. It was the logical way to go if I want to pursue an academic career. I really wanted to continue my project, and I eventually got the funding to do so.'* Those answers were consistent with the initial plans, well received introduction to the lab and subsequent follow up. The paths of remaining four students were more complicated. Two of them were unable so far to launch their PhDs and answered: *'I'm considering it. I want to do research on my own project. I think PhD research will help to improve my abilities to understand and solve problems, increase confidence, make me a better communicator and gain skills that may lead to a better job, even in many fields apart from academics.'* and *'I am applying for it. Apart from qualifications, networking plays an important role in Denmark. So, I guess it could be challenging to find a good project, however, I try my best for expanding my future career.'* This clearly indicates that they would accept or are actively searching for PhD opportunities but for different reasons are unable to find their place and founding.

The remaining two students that did not want to become PhDs and the time in the lab did not change their position, answered along the following line: *'I want to have a "regular" job where I don't need to think about work when I come home, which I believe writing a PhD might.'* But importantly none of them reported that the period spend in our laboratory had a negative impact on their plans. They all seem to be supported in the choices they made and had been given the opportunity to experience by themselves how difficult but fascinating the research is. However again, in my survey I have not encountered students that estimated their introduction to the lab as insufficient or negative and thus I cannot evaluate if such a 'bad' introduction has really a negative impact on students' professional choices.

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Part IV

Strengthening inductive teaching

9

Analysis for implementing an inductive learning in a MSc course

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Introduction

The present project focuses on the analysis for implementing a new practical work for the MSc course "Dairy Product Technology" (DPT) (http://kurser.ku.dk/course/llek10243u/). DPT is a compulsory course of the MSc program in **Dairy Science and Technology at the University of Copenhagen**, scheduled in the 4th block of the academic year. The work load is equal to 206 work hours and the students obtain 7.5 ECTS. The course includes a theoretical part, which accounts for 25 hours of face-to-face lectures, a practical part that includes a project (64 hours), and excursions to dairy companies (24 hours). Self-study, hence preparation for the exam, is estimated to 66 hours. In addition, 12 hours of supervision are offered. The project work focuses on a theoretical exercise and on three practical work exercises. The aim of the theoretical exercise is to discuss a current topic in dairy research suggested by the course responsible. Students work in groups and a short report based on existing literature is delivered. The three practical works focus on topics covered by the theoretical part. Also in this case students work in groups and deliver a report based on the obtained results. The main objective of the project work is: *"to provide students with in-depth knowledge of research within a self-chosen subject related to dairy technology"*. The intended learning outcomes (ILOs; http://kurser.ku.dk/course/llek10243u/) are well designed to be highly operational and functional, and it emerges that the main objective of the course is to be able to convert knowledge and skills in competences. In my opinion the proposed objective and ILOs are not fully achieved by the current practical work. I believe that the current practical work does not fully provide students with *"in-depth knowledge of research"*, *"ability to reflect on how the final product quality, hence the colloidal interactions occurring in dairy-based systems, is affected by the technology behind manufacture"*, *"ability to apply the principle of colloidal science to processing of dairy products"*, and to *"interact with professionals in the dairy industry and associated organizations"* (ILOs). If the students need to be able to convert knowledge and skills in competences, I believe that a more applied project, as inductive learning (Dewey, 1981) should be implemented. Inductive learning is a method of teaching and learning, which awards students with knowledge, skills and competences relevant for their professional working life. Inductive learning can be described as a tool to link theory and practice (Krogh & Wiberg, 2015).

Objective

The present work aims to perform an analysis for implementing inductive learning in an MSc course. The focus is on the analysis of the resources needed, on the objectives´ alignment among the teachers, and on the student's situation. A possible approach is hereby suggested

Analysis and expected challenges

The utmost aspect to consider before applying the change should be the investment in **resources**, such as availability for teaching/learning environments, and for supervisors. When evaluating the *teaching/learning environments* care should be taken for availability of laboratories and technical instruments for all the students. The work environment should be suitable for a large number of students as the number of students is dramatically increasing (from 20 students in 2014 to 40 in 2015). In addition, laboratories as well as technical instruments are often shared with other students and researchers. Therefore it should be taken in consideration that the period to perform the practical project should not interfere with the on-going research of the department. Another import resource needed is the availability of *supervisors* and *technicians*. The role of the supervisors should be first to plan the project accordingly to the objective and ILOs of the course, which should be highly relevant and motivating for the students. Supervisors and/or technicians should be available to introduce and instruct the students to the different analytical methods, and for assistance during the practical period. The supervisors should also be available for the final assessment. Consequently, a considerable investment in time and on different resources, as supervisors, laboratories, technical instruments and materials, should be expected. In order to have a positive engagement from the supervisors, it is important that the time spent on the planning and on the performance of the project should be beneficial to them. This could be achieved by involving PhD, Postdoc and researchers and rewarding the time spent on it either as ECTS for PhD students, and as teaching activities hours for Postdoc and researchers (as it is already done in most of the cases). In addition, the project work could be designed as screening project to evaluate the potential of the topic for further investigations.

Another important aspect to consider before implementing the practical work is the **objectives´ alignment** among the teachers involved in the course. The course responsible and the teachers involved in the course should agree on the benefits that this change will bring to the students and to the course. It is important to have all management on board, and clarify the task and responsibilities of the different people involved. The latter can be a crucial point for a successful course, especially the first time that the practical work will be implemented. A lack in objectives´ alignment can result in students´ frustration.

The **student's situation** should also be carefully evaluated. The level of expectation for the course is going to be raised; therefore a good communication plan should be implemented. The *communication plan* should be formulated in order that a clear goal and structure of the changes in the course need to be presented, including the benefits for the students. This part of the course should be emphasized in the course description. A project based on inductive learning can be *more demanding* than the current practical work, therefore it is expected a higher amount of working hours. Increasing the amount of ECTS cannot be considered as a feasible solution. However, the hour's distribution can be revised, and more hours can be allocated to the project work; e.g. excursions' hour can be used to visit the companies willing to support and supervise the projects, and a presentation and a preliminary discussion of the problem can already take place; supervisions' hours can also be used during the project. The student situation is also reflected in the *engagement required* from the students. Generally, students prefer practical and active learning activities; and students who are familiar with inductive learning describe it as *"more interesting, motivating and rewarding than traditional teaching approach"* (Krogh, Stentoft, Emmersen, & Musaeus, 2013). However, some students are used to have a role as passive acceptor, and in order to avoid confusion and frustration they should be introduced and encourage in performing a project based on inductive learning, therefore change their role to *"active learner"* (Krogh et al., 2013). By changing the focus from a theoretical to a practical exercise I would expect higher students´ motivation, moreover it promotes skills and knowledge as student do not just observe but actively participate in the learning, and their attention is higher than in a face-to-face lecture (P. S. Jørgensen, 2015). Students familiar with inductive learning have higher ability to "know-how", and to use a holistic approach in their future work career for solving work related problems. In addition, they also develop communicative, teamwork and project management competence (Krogh et al., 2013; S. Jørgensen, 2015).

Suggested approaches

Once that the above mentioned challenges have been analyzed, and the teachers agree on the implementation of a project based on inductive learning, the *subjects* of the projects should be carefully selected. I believe that the key point to have a successful outcome is to identify project topics with high impact on student motivations and engagement. In addition, it is important to guide the students with specific research questions, as the limited time available can lead to students' frustration and confusion on the purpose of the activity. Therefore, limit the scope of the project is critically necessary. Involve *external teachers/supervisors* can also be attractive for the students. In order to have both students and supervisors involved in the practical projects, I suggest involving PhD, Postdoc, and Researchers from both academia and companies to propose and supervise their own project. I believe that this approach should get the students involved and supervisors attached to each project.

Figure 9.1 proposes the different phases of an inductive learning projects. The order of the different phases can change based on the topic of the project and on the students´ approach, as they often work simultaneously with two or more phases, e.g. identification and solution of the problem. The supervisor should follow the students in all phases and he/she should make sure that the student understand the concept of "solution of the prob-

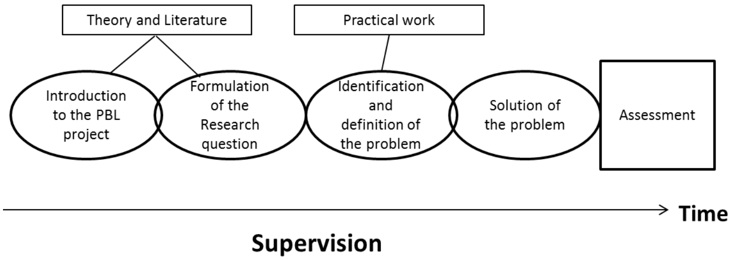

Fig. 9.1: Different phases for inductive learning projects (modified by Krogh and Wiberg (2015)).

lem", as it should be intend as to elaborate and define a problem rather than finding the final solution (Krogh & Wiberg, 2015). The overall aim should be to define the research questions initially formulated by developing one or more solution if needed.

The role of the supervisors should be seen as a *facilitator* of student´s work (Krogh et al., 2013). The supervisor should make sure that the formulated research question, the theory and the approach to solve the problem are according to the ILOs of the course. Whereas, the students' role is to identify and solve the problem, by applying skills and knowledge via competences (Figure 9.2). Theory and literature must be at the base of a project, as it is needed by the student to analyze and further identify and solve the research question (Figure 9.1-9.2).

Conclusions

Based on a preliminary analysis hereby presented, I would strongly recommend implementing inductive learning to the MSc course in DPT. In order to succeed with the implementation and performance of the practical work, the most important initial point, after evaluating the resources, should be the positive engagement from all the people involved. If expectations and ILOs are aligned among the teachers, the implementation can be considered successful.

I believe that the main contribution for implementing inductive learning project is that the students will learn to acquire knowledge and skills in a holistic approach which will contribute to stimulate their creativity. In addi-

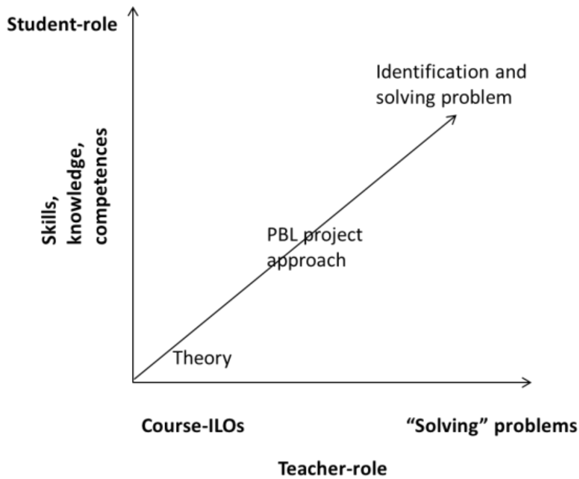

Fig. 9.2: Theacher and student role during inductive learning based project (modified from Krogh, Stentoft, Emmersen, and Musaeus (2013))

tion, it will create graduates who are able to solve and to deal with problem-solving task during their future work career. This is highly reflected in the proposed objective and ILOs of the course, as the project work and the ILOs are better aligned.

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10

Omstrukturering af undervisning imod en mere induktiv tilgang

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English summary

In my teaching I have experienced that students are reluctant to engage and be active in the class room, which may have adverse effects on their learning. Potential barriers include; large class room setting (approx. 80 students) where students don't know each other, a deductive organization of the teaching centered around the delivery of de-contextualized general knowledge and definitions, and the availability of the teacher's slides, containing all the definitions and answers to questions raised by the teacher during class, before class starts.

To foster student engagement and to facilitate deep learning of the intended learning outcomes (ILO's), I restructured the teaching to a more inductive form centered on students' group work with relatable cases and concrete examples (re-contextualization) promoting personalization of the material in didactic environments supporting students' own academic insight into the ILO's through the didactic phases of action, formulation and validation.

My role as teachers in this work was primarily to devolve the didactic environments to the students and later to paraphrase students points from interacting with the didactic environment and provide validation (along with the fellow students) and to institutionalize students own insights according with the more general ILO's.

The introduction of Shakespeak clikkers as part of the group work increased students engagement and active participation, and quickly also their understanding of the increasingly more complex examples (still more

students answered the quizzes and also got the answers right). The introduction of a pre-class online quiz in Absalon provided insight to students learning based on the curriculum alone (for students as well as the teacher) highlighting the most difficult aspects of the teaching to put extra focus on during the class room teaching. The restructuring of the teaching with case-based relatable examples and quizzes increased student engagement and was highly valuated by the students in the following evaluation.

Kort beskrivelse af kurset og de studerende

Kurset er et metodefag i Epidemiologi på Folkesundhedsvidenskabs overbygning. De studerende har tidligere haft basal epidemiologi på 1. semester af deres bacheloruddannelse, og faget bygger således videre på begreber de tidligere har stiftet bekendtskab med. De studerende kommer fra forskellige universiteter og kender ikke alle hinanden, og har ikke samme faglige forudsætninger i forhold til epidemiologi. Begge forhold kan virke som barrierer i forhold til at deltage aktivt i undervisningen. Forelæsningerne holdes for ca. 70-80 studerende, hvilket ligeledes kan afholde nogle studerende fra at deltage aktivt (jf. erkendelse fra vores pre-project).

De studerende har almindeligvis adgang til underviserens PowerPoint præsentationer i Absalon inden undervisningen starter, hvilket giver dem mulighed for at kommentere direkte i præsentationen under undervisningen. En ulempe ved dette er imidlertid, at de studerende typisk vil have underviserens spørgsmål såvel som svar, og definitioner på kernebegreber allerede inden undervisningsgangen. Dette kan have den konsekvens at de studerende i mindre grad engagerer sig i selve undervisningen og er mindre motiverede for at deltage aktivt.

Således kan undervisningssituationen, med et stort antal studerende med en blandet baggrund, såvel som en meget klassisk forelæsningsopbygning centreret omkring definition af kernebegreber, som er tilgængelig allerede før selve forelæsningen, have den konsekvens at de studerende kun i begrænset omfang deltager aktivt i undervisningen. Det manglende engagement kan have en negativ effekt på de studerenes læring, da vi ved teoretisk såvel som erfaringsbaseret, at indlæring (for de flestes vedkommende) er langt mere effektivt når man arbejder aktivt med materialet. Fra underviserens perspektiv skaber det ydermere usikkerhed om, hvorvidt læringsmålene er forstået af de studerende.

En måde at øge de studerenes engagement kan være, at omstrukturere undervisning fra en deduktiv form (centreret omkring information leveret *fra* underviseren *til* de studerende bygget op omkring definitioner), til en mere induktiv form, som i højere grad er centreret omkring inddragelse af relaterbare konkrete cases og eksempler i forelæsningen med brug af definitioner udelukkende til at samle op til slut i undervisningen. Tilsvarende kan IT bruges mere interaktivt som et virkemiddel til aktivt at inddrage de studerende på anden vis end de mere klassiske forelæsninger.

Derfor er formålet med mit afsluttende projekt

- At undersøge hvordan omstrukturering af forelæsningerne fra en deduktiv til mere induktiv tilgang (understøttet af teorien om den didaktiske situation) påvirker de studerenes engagement i undervisningen, samt forståelse af læringsmålene.

Relevansen af nærværende emne bunder i betydningen af at gøre undervisningen relevant og nærværende for de studerende, vigtigheden af at engagere de studerende i undervisningen og få dem på banen aktivt ved hjælp af en mere induktiv case-baseret undervisning, hvilket kan understøtte de studerenes engagement og indlæring; frem for den nuværende deduktive tilgang, som bygger mere på *levering* af abstrakt viden fra underviseren til de studerende.

Beskrivelse af undervisningssituationen

Læringsmålene for den konkrete undervisningsgang er i høj grad centreret omkring de studerenes forståelse af og kompetencer i forhold til anvendelse af nøglebegreber indenfor emnet ”misklassifikation”, hvor de blandt andet skal kunne genkende og grafisk illustrere nøgleproblemstillinger i forhold til emnet.

I den omstrukturerede undervisning inddrages en relaterbar case helt indledningsvist, efterfulgt af afledte konkrete øvelser (som stiger i kompleksitetsgrad). Første case handlede om alkohol indtag under graviditeten og mulig risiko for autisme hos det ufødte barn. For at understøtte de studerendes villighed til at bidrage til diskussionen af øvelserne, vil der ligeledes blive lagt mere vægt på at give de studerende mulighed for at snakke sammen med sidemanden om casen og øvelserne, samt (afhængig af øvelserne) lade dem svare digitalt vha. clikkere i Shakespeak inden svarene diskuteres i plenum.

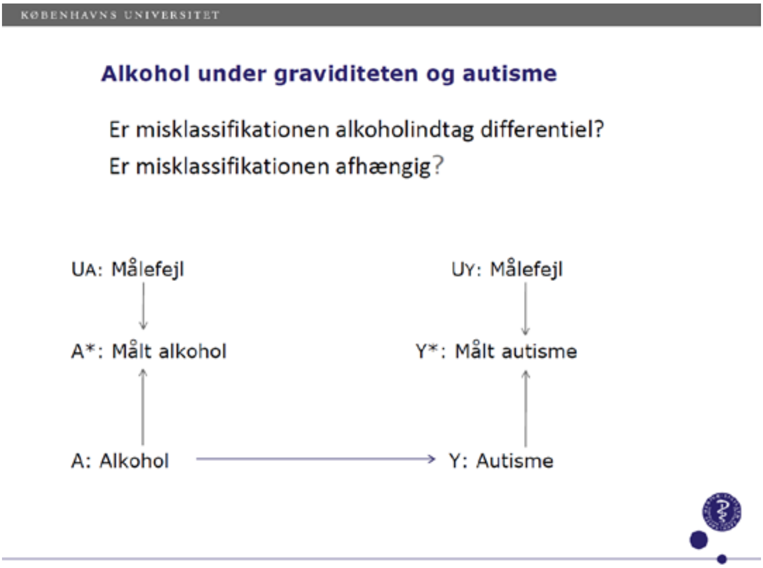
To eksempler på Shakespeak-øvelser fra undervisningen er illustreret i Figur 10.1 nedenfor. Efter at have diskuteret hver af de to viste slides med sidemanden, kan de studerende afgive deres svar anonymt vha. clikkers.

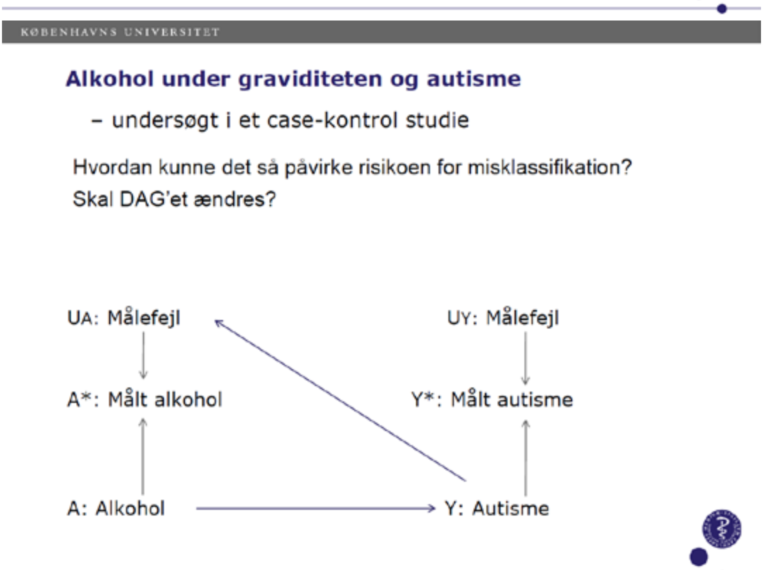
Tidlig inddragelse af konkrete og relevante problemstillinger tænkes at understøtte de studerens forståelse af hvad der karakteriserer disser i forhold til misklassifikation, forståelse af hvordan de forskellige problemstillinger kan illustreres grafisk, samt fungere som illustration af relevansen af brugen af disse i forståelsen af stoffet (i forhold til læringsmålene).

For at modvirke passivitet pga. udleverede svar of definitioner på slides før undervisningsgangen, vil de korrekte løsninger til de diskuterede øvelser samt definitioner til kernebegreberne først blive tilføjet PowerPoint præsentationen i en ny version som gøres tilgængelig efter forelæsningen. Således er pilen fra 'autisme' til 'målefejl' i Figur 10.1 ikke inkluderet i de studerenes version af præsentationen før undervisningsgangen og pilen er først synlig efter de studerene har afgivet deres stemme.

Derudover vil de studerende som noget nyt få mulighed for at arbejde med problemer direkte relateret til læringsmålene inden undervisningsgangen i en onlinequiz på Absalon (Bilag A). Dette vil give dem en mulighed for at vurdere deres egen forståelse af materialet efter læsning af pensum, ruste dem bedre til at indgå i diskussion af problemstillinger de allerede har stiftet bekendtskab med, samt give underviseren et indblik i hvad der var særligt vanskeligt at forstå (ud fra de studerenes besvarelser), og dermed hvad der skal lægges mest vægt på i undervisningen. Hvert spørgsmål i quizzen efterfølges af en beskrivelse af *hvorfor* et givent svar var korrekt/forkert, således at de studerende får en mere konstruktiv feedback på deres svar end blottet en samlet score eller angivelse af korrekte og forkerte svar.

De studerenes oplevelse af den øgede brug af cases og øvelser, såvel som brug af IT i form af clikkere og online quiz vurderes vha. plenumdiskussion efter undervisningen til kursets midtvejsevaluering. Her har de studerens bl.a. har mulighed for at diskutere kurset (inkl. omstruktureringen af denne undervisningsgang) uden at underviserne er til stede og give en samlet feedback. Denne evalueringsform giver de enkelte studerende en anonymitet i forhold til at komme med kritik at undervisningen, som de måske ellers ville være tilbageholdne med.





Figur 10.1: To eksempler på Shakespeak-øvelser fra forelæsningen, centreret omkring samme case om alkoholindtag under graviditeten og risiko for autisme hos det ufødte barn. Pilen fra 'autisme' til 'målefejl' er ikke synlig i de studerenes version af præsentationen før undervisningsgangen.

Strukturering af undervisningsgangen med udgangspunkt i teorien om den didaktiske situation

Læringsmålene for undervisningen bygger hovedsagelig på generel (de-konteksutaliseret) viden, hvilket kan være medvirkende til at undervisningen tidligere har været meget deduktivt opbygget omkring definitioner som institutionaliseret viden, der imidlertid kan være svære at relatere til. Til trods for denne type læringsmål vil det ofte være utilstrækkeligt at underviseren blot *leverer* denne viden til de studerende. For at understøtte de studerendes egne erkendelser af den tilsigtede generelle viden bliver denne nød til at blive re-kontektualiseret (sat ind i en konkret kontekst) i et didaktisk miljø, som de studerende kan relatere til for at denne kan blive integreret som personlig viden hos de studerende ('personificering').

Med det udgangspunkt at vi lærer bedst via relation til konkrete situationer bevirker casen samt øvelserne således til at re-kontekstualisere den tilsigtede (de-kontekstualisrede) viden lige fra undervisningsgangs start. Tidlig inddragelse af casen samt efterfølgende øvelser driver derudover motivationen hos de studerende som formodes at kunne relatere til casen og de opstillede problemstillinger personligt og/eller i kraft af deres nuværende og fremtidige virke som "Folkesundhedsvidenskabere".

For at støtte op om de studerens indlæring skabes didaktiske miljøer hvor de studerende sammen i grupper af 2-3 kan diskutere problemstillingerne i den opstillede case og de efterfølgende øvelser, før disse præsenteres og diskuteres i plenum. Casen, der som handler om effekten af alkoholindtag under graviditeten for det ufødte barn, er som nævnt udformet ud fra et kriterium om at være både relaterbar for de studerende og af bred folkesundhedsmæssig relevans. Hensigten med dette er at stimulere 'personificering' af stoffet, hvorved den studerende kan skabe en relation til egen situation fx fremtidig arbejdssituation, hvilket understøtter indlæringen af relevant viden.

I forhold til de forskellige faser af det didaktiske spil er undervisningen struktureret således at der efter et kort oprids af hvordan dagens lektion placerer sig i forhold til kursets overordene opbygning og målsætning indledes med 'devolution' af den opstillede case omkring alkoholindtag under graviditeten. Her sætter underviseren rammerne for det didaktiske miljø og giver de studerende den fornødne viden til sammen med sidemanden at kunne diskutere problemerne med måling af alkohol i forhold til casen ('aktionsfasen'). Efter at have arbejdet med stoffet formulerer de studerende deres overvejelser/indsigter sammen i plenum i 'formuleringsfasen'. 'Formuleringsfasen' er imidlertid tæt sammenknyttet med aktionsfasen idet de studerende indbyrdes forelægger og diskuterer problemstillingerne. I denne proces foregår ligeledes 'adidadktisk validering' som et naturligt element af den indbyrdes diskussion imellem de studerende. Efterfølgende præsenterer de studerende deres indsigter i plenum og indsigterne valideres af de øvrige studerende og af underviseren ('valideringsfasen'), som parafraserer de studerenes generelle såvel som specifikke centrale pointer i forhold til læringsmålene. Slutteligt relateres de studerenes pointer fra interaktionen med det didaktiske miljø til de mere generelle temaer for undervisningsgangen i 'intsitutionaliseringsfasen', hvilket er medvirkende til at understøtte den 'delte' viden som ligeledes kan anvendes udenfor dette didaktiske miljø (en 'adidaktisk' situation).

De efterfølgende øvelser følger en lignende opbygning i forhold til det didaktiske spil med præsentation af rammen for øvelserne og guide i retningen af hvormed der skal arbejdes med stoffet ('devolution'); de studerendes par-arbejde med øvelserne i det didaktiske miljø ('aktion'); de studerenes præsentation af mulige løsninger på øvelserne (ved hjælp af clikkers i Shakespeak i flere tilfælde) ('formulering'); plenumdiskussion af de foreslåede løsninger ('validering'); og sammenfatning af de studerenes specifikke og generelle pointer i forhold til det didaktiske miljø, men også som mere 'abstrakt' viden indenfor emnefeltet – mere general viden som også kan appliceres i andre situationer ('institunalisering').

Tilsammen udgør de studerenes diskussion af den opstillede case samt de gradvist mere komplekse øvelser didaktiske miljøer, hvori de studerende sammen kan indgå i det didaktiske spil for at nå til erkendelser omkring de opstillede læringsmål. Ved gradvist at bygge videre på forudgående øvelser guides de studerende hele tiden videre i den rigtige retning mod svaret, da de skal bygge videre på erkendelser de har gjort i øvelserne forinden. Dette bevirker derudover at underviserens rolle i de studerendes aktion, formulering og validering forbliver begrænset selvom kompleksiteten af øvelserne gradvist øges. De didaktiske miljøer er således heller ikke uafhængige, og indsigterne fra foregående øvelser videreudvikles i de efterfølgende øvelser. De to øvelser i Figur 10.1 er eksempel på dette.

Først efter at de studerende har arbejdet med stoffet i flere didaktiske miljøer, præsenteres de for de mere de-kontekstualiserede begreber som sammenbinder de indsigter der er gjort under de didaktiske spil centreret omkring de specifikke didaktiske miljøer for casen og øvelserne.

Erfaringer/erkendelser efter afholdt omstruktureret undervisning

Under og efter forelæsningen erfarede jeg, at omstruktureringen til en mere induktiv form centreret omkring casen og på de understøttende eksempler og øvelser, i højere grad end tidligere engagerede de studerende. Den tidlige inddragelse af disse fik dem til at diskuterer fagligt med hinanden helt fra start af undervisning – de indgik engageret i de didaktiske spil – og var mere villige til at komme på banen med input og spørgsmål, fordi de havde haft mulighed for at diskuterer problemstillingerne indbyrdes i mindre grupper, forinden plenumdiskussionen. Ved den første Shakespeak øvelse overhørte min supervisor en studerende sige: ”Shit, nu skal vi selv forholde os til det!” Jeg synes citatet er illustrativt i forhold til behovet for konkret og tidligt at involverer de studerende for at holde dem engagerede. Igennem de fire Shakespeak øvelser, som alle var centreret omkring den samme problemstilling (med at karakterisere grafiske illustrationer af gradvist højere kompleksitetsniveau) kunne jeg ligeledes se, 1) at gradvist flere studerende besvarede øvelserne 2) at de var stadigt hurtigere til at svare, 3) at stadigt flere svarede rigtigt.

Ved evaluering efter forelæsningen fik jeg mulighed for direkte at spørge de studerende ind til deres oplevelse den øgede inddragelse af case og øvelser med brug clikkere såvel som online quiz før undervisningen. Jeg fik den tilbagemelding, at inddragelsen af clikkere ofte virker som aktivering for aktiveringens skyld og kan blive ”gimmicky”, men at det i denne sammenhæng rent faktisk havde fungeret efter hensigten. De vurderede selv af inddragelse af casen og øvelserne havde fået dem i gang med at diskuterer stoffet og hjulpet dem med at hjælpe hinanden til at forstå nøglebegreberne. Min faglige supervisor sagde: ”Jeg har aldrig set det (brug af Shakespeak clikkere red.) fungere så godt før”, hvilket bakker op om den oplevelse jeg selv havde med brugen af øvelserne og Shakespeak i denne sammenhæng – at det engagerede de studerende, gjorde dem interesserede og virkede til at understøttede deres læring.

Muligheden for at kunne tage en online quiz relateret til læringsmålene var ligeledes noget de studerende var meget glade for. Få tekniske udfordringer blev pointeret (som nemt kan udbedres til næste gang kurset skal køre). Baseret på de studerens besvarelse af quizzen inden undervisningsgangen fik jeg ligeledes indblik i hvad der var de svære områder i forhold til læringsmålene, hvorfor jeg lagde ekstra vægt på disse i undervisningen.

Overvejelser i forhold til min undervisning fremadrettet

Med udgangspunkt i de erfaringer jeg har gjort mig med dette projekt, vil jeg langt mere bevidst strukturere undervisningen ud fra et induktivt princip således at den i højere grad er drevet af motiverende relaterbare cases og øvelser frem for deduktiv levering af de-kontekstualiseret viden. Jeg vil mere bevidst gå ind i planlægningen af undervisningen ud fra opstillingen af målrettede didaktiske miljøer, som er befordrende for de studerens interaktion og læring, og fortrinsvist benytte definitioner i opsamlinger i det omfang at det giver mening i den givne situation.

Jeg vil fortsætte med at køre med en 'før' og en 'efter' version af PowerPoint præsentationer i undervisningen, således at de studerende ikke får svar of definitioner udleveret før undervisningen. Dette var med til at holde dem nysgerrige og motiverede for at deltage aktivt i undervisningen.

Jeg vil derudover arbejde videre med udformningen af online quizzer til de øvrige af kursets moduler, til at guide prioriteringen af undervisningen og som hjælp til de studerenes selvevaluering i forhold til de opstillede læringsmål.

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A Eksempler på spørgsmål fra quizzen om misklassifikation

1) Overvejelser vedrørende misklassifikation er relevante i forhold til:

a) Eksponeringer
b) Udfald
c) Confoundere
d) Mediatorer i mediationsanalyser

→ Feedback (a-d): Misklassifikation af alle parametre i ens analyse kan påvirke resultaterne; eksponeringer, udfald, og inkluderede confoundere (samt mediatorer i mediationsanalyser). Konsekvenserne afhænger af typen og graden af misklassifikation.

e) Ingen af ovenstående
f) Ved ikke

→ Feedback (e,f): Forhåbentlig bliver det mere klart efter undervisningen, at misklassifikation af alle parametre i ens analyse kan påvirke resultaterne; eksponeringer, udfald, og inkluderede confoundere (samt mediatorer i mediationsanalyser). Konsekvenserne afhænger af typen og graden af misklassifikation.

2) Overvejelser vedr. misklassifikation er relevante i forhold til:

a) Kun deskriptive forskningsspørgsmål fx hvor stor en andel af danske unge (<18 år) ryger?
b) Kun kausale spørgsmål fx røgfrie miljøer på uddannelsesinstitutioner reducerer andelen af unge der begynder at ryge?
c) Både deskriptive og kausale forskningsspørgsmål.
d) Hverken deskriptive eller kausale forskningsspørgsmål.
e) Ved ikke.

→ Feedback (a-e): Overvejelser vedr. misklassifikation er relevante i forhold til deskriptive såvel som kausale forskningsspørgsmål. Fx kan forekomsten af en risikofaktor ikke korrekt beskrives, hvis denne ikke er korrekt identificeret. Tilsvarende kan den estimerede effekt skævvrides pga. misklassifikation af eksponering, udfald og/eller confoundere. Konsekvenserne af misklassifikation afhænger af typen (differentiel vs. non-differentiel og afhængig vs. uafhængig misklassifikation) og graden af misklassifikation (større eller mindre grad af misklassifikation).

3) I forhold til misklassifikation af udfaldet er det særligt relevant at overveje hvorvidt:

a) Man skal ikke overveje betydningen af misklassifikation af udfaldet.
b) Misklassifikation af udfaldet er ens eller forskellig for folk med forskellig eksponering.
c) Om målefejlene på udfaldet er afhængig af målefejl på eksponeringen.

→ Feedback (a-c): For at kunne vurdere konsekvenserne af misklassifikation af udfaldet er det væsentligt at vurdere om den er ens eller forskellig for folk med forskellige eksponeringsniveauer – om den er differentiel med hensyn til eksponering – samt om målefejlene for eksponering og udfald er afhængige.

d) Misklassifikationen er større/mindre blandt de som har afslået at deltage i studiet.

→ Feedback (d): For at kunne vurdere konsekvenserne af misklassifikation af udfaldet er det væsentligt at vurdere om den er ens eller forskellig for folk med forskellige eksponeringsniveauer – om den er differentiel med hensyn til eksponering – samt om målefejlene for eksponering og udfald er afhængige.

Vurdering af misklassifikation er noget vi gør i forhold til de som er med i studiet. Mere generelt er en vurdering af forskelle mellem deltagere og ikke-deltagere, der har afvist at være med i studiet, normalt ikke noget vi vurderer i forhold til misklassifikation, men overvejelser der kan være relevante i forhold til vurdering af selektions bias.

4) **Misklassifikation af en eksponering (af fx fedme) kan opstå bl.a. på grund af.:** (flere svar kan vælges)

   a) Mangelfuld randomisering.

→ Feedback (a): Kilder til misklassifikation kan finde sted både i konceptualiseringen af det ætiologisk relevante eksponeringsmål for den undersøgte sammenhæng og i implementeringen af det operationelle mål, ved uhensigtsmæssig kategorisering, ved bevidst/ubevist fejl i selvrapportering, samt ved tilfældige fejl i måling og/eller registrering af eksponeringen.

I et randomiseret studie opstår der misklassifikation af den randomiserede eksponering ved mangelfuld komplians (ikke ved mangelfuld randomisering). Mangelfuld randomisering kan medføre at eksponeringsgrupperne ikke er ombyttelige med hensyn til kendte såvel som ukendte confoundere. Uhensigtsmæssig udvælgelse af kontroller i et case-kontrol studie medfører selektions bias, ikke misklassifikation.

   b) Mangelfuld konceptuel definition af eksponeringen fx forskerne mente at det var BMI der var det relevante mål for fedme i forhold til risikoen for hjertekarsygdom, men i realiteten var det central fedme der var det ætiologisk relevante mål for fedme i denne årsagssammenhæng.
   c) Mangelfuld komplians med randomiseret eksponering (analyseret efter intention to treat princippet).
   d) Mangelfuld/fejlbefængt måling af den korrekt definerede relevante eksponering (BMI var det korrekte mål i forhold til fedmes effekt på hjertekarsygdom, men det selvrapporterede mål for højde og vægt brugt i undersøgelsen var fejlbefængt).
   e) Uhensigtsmæssig udvælgelse af kontroller i et case-kontrol studie.
   f) Uhensigtsmæssig kategorisering af eksponeringen.
   g) Tilfældig fejl (fx pga. fejl i højdemåler/vægt til at fastslå BMI eller fejlregistreringen af eksponeringen ved indtastning af spørgeskemaer).
   h) Bevidst eller ubevidst fejl i selvrapportering.
   i) Tilstedeværelsen af sygdom (fx præklinisk sygdom) som kan påvirke målingen af eksponeringen (fx i blodprøve).
   j) Mangelfuld randomisering.

→ Feedback (b-j): Kilder til misklassifikation kan finde sted både i konceptualiseringen af det ætiologisk relevante eksponeringsmål for den undersøgte sammenhæng og i implementeringen af det operationelle mål, ved uhensigtsmæssig kategorisering, ved bevidst/ubevist fejl i selvrapportering, samt ved tilfældige fejl i måling og/eller registrering af eksponeringen.

I et randomiseret studie opstår der misklassifikation af den randomiserede eksponering ved mangelfuld komplians (ikke ved mangelfuld randomisering). Uhensigtsmæssig udvælgelse af kontroller i et case-kontrol studie medfører selektions bias, ikke misklassifikation.

   k) Ved ikke.

→ Feedback (k): Efter undervisningen er det forhåbentlig mere klart, at kilder til misklassifikation kan finde sted både i konceptualiseringen af det ætiologisk relevante eksponeringsmål for den undersøgte sammenhæng og i implementeringen af det operationelle mål, ved uhensigtsmæssig kategorisering, ved bevidst/ubevist fejl i selvrapportering, samt ved tilfældige fejl i måling og/eller registrering af eksponeringen.

I et randomiseret studie opstår der misklassifikation af den randomiserede eksponering ved mangelfuld komplians (ikke ved mangelfuld randomisering). Uhensigtsmæssig udvælgelse af kontroller i et case-kontrol studie medfører selektions bias, ikke misklassifikation.

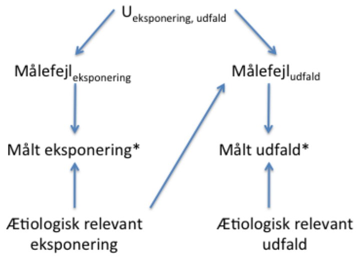
5) **Lige såvel som confounding kan klassificeres som en åben bagdør og selektionsbias som betingning af en fælles effekt af eksponering og udfald (eller årsager til disse), kan misklassifikation karakteriseres ved én fælles struktur i et DAG:**

a) Sandt
b) Falsk
c) Ved ikke

→ Feedback (a-c): Påstanden er falsk - misklassifikation kan ikke beskrives ved én fælles struktur i et DAG.

Misklassifikation af henholdsvis eksponering og udfald kan illustreres i et DAG med hensyn til om misklassificeringen er 1) differentiel/non-differentiel (mht. udfald/eksponering) og 2) om målefejlene er afhængige/uafhængige, hvilket giver anledning til forskellige strukturer i et DAG.

6) DAG'et illustrerer:



a) Uafhængig differentiel misklassifikation af udfaldet.

→ Feedback (a): Nej, dette er ikke et eksempel på uafhængig differentiel misklassifikation af udfaldet.

Der er korrekt at misklassifikationen af udfaldet er differentiel med hensyn til eksponeringen idet den sande værdi af eksponering påvirker målefejlen på udfaldet. Men den bagvedliggende faktor U(eksponering,udfald) forbinder målefejlene på eksponering og udfald, hvorfor misklassifikationen er afhængig.

Der er således tale om afhængig differentiel misklassifikation af udfaldet.

b) Uafhængig differentiel misklassifikation af eksponeringen.

→ Feedback (b): Nej, dette er ikke et eksempel på uafhængig differentiel misklassifikation af eksponeringen.

Da den sande værdi af eksponering påvirker målefejlen på udfaldet er misklassifikationen af udfaldet differentiel med hensyn til eksponeringen. Den bagvedliggende faktor U(eksponering,udfald) forbinder målefejlene på eksponering og udfald, hvorfor misklassifikationen er afhængig.

Der er således tale om afhængig differentiel misklassifikation af udfaldet.

c) Uafhængig non-differentiel misklassifikation.

→ Feedback (c): Nej, dette er ikke et eksempel på uafhængig non-differentiel misklassifikation.

Da den sande værdi af eksponering påvirker målefejlen på udfaldet er misklassifikationen af udfaldet differentiel med hensyn til eksponeringen. Den bagvedliggende faktor U(eksponering,udfald) forbinder målefejlene på eksponering og udfald, hvorfor misklassifikationen er afhængig.

Der er således tale om afhængig differentiel misklassifikation af udfaldet.

d) Afhængig non-differentiel misklassifikation.

→ Feedback (d): Nej, dette er ikke et eksempel på afhængig non-differentiel misklassifikation.

Da den sande værdi af eksponering påvirker målefejlen på udfaldet er misklassifikationen af udfaldet differentiel med hensyn til eksponeringen. Men det er korrekt at misklassifikationen er afhængig idet den bagvedliggende faktor U(eksponering,udfald) forbinder målefejlene på eksponering og udfald.

Der er således tale om afhængig differentiel misklassifikation af udfaldet.

e) Ved ikke.

→ Feedback (e): Efter undervisningen er det forhåbentligt mere klart at dette er et eksempel på afhængig differentiel misklassifikation af udfaldet.

Da den sande værdi af eksponeringen påvirker målefejlen på udfaldet er misklassifikationen af udfaldet differentiel med hensyn til eksponeringen. Den bagvedliggende faktor U(eksponering,udfald) forbinder målefejlene på eksponering og udfald, hvorfor misklassifikationen er afhængig.

Der er således tale om afhængig differentiel misklassifikation af udfaldet.

f) Afhængig differentiel misklassifikation af udfaldet.

→ Feedback (f): Ja, dette er et eksempel på afhængig differentiel misklassifikation af udfaldet.

Da den sande værdi af eksponeringen påvirker målefejlen på udfaldet er misklassifikationen af udfaldet differentiel med hensyn til eksponeringen. Den bagvedliggende faktor U(eksponering,udfald) forbinder målefejlene på eksponering og udfald, hvorfor misklassifikationen er afhængig.

11

Case- and problem-based group assignments and the effects of formative feedback

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Introduction

In a common setting of teaching process, the mutual interactions between the students and the teacher can be illustrated as continuous stream of information exchanges by utilizing teaching materials, lectures, assignments, presentation and evaluations. According to the teaching portfolio and predefined ILOs (intended learning outcomes), the ultimate objective of the teaching process would be to improve the experiences of both parties - teachers and students – in a positive notion, meanwhile, maintaining high evaluation marks, with minimum inputs of resources. Among many prerequisite resources in a teaching process, time is the one of the most important factors, which can determine the quality of teaching and learning outcomes from the teachers' point-of-view. The balance between research and teaching is tedious to achieve and time-consuming process is inevitable. In this sense, it is critical to manage good quality of teaching with high quality research to maintain the research group more recognized in a field of science, which can tremendously stimulate the teaching process with obtained authority and attractive forces for students in the classroom as well.

Here I describe how the burdensome of teaching process can quickly be optimized by using web-based formative feedback process, which can minimize time resource, while providing high quality information to students in their learning process. The course title is: Reactions and Synthesis in Medicinal Chemisty for MSc students (2 blocks, 15 ECTS, 48 students, 2 teachers). The group assignments were designed to serve as case-based (Wassermann, 1994) and problem-based learning (PBL) materials to create active-learning process. The provided feedback (Hattie & Timperley, 2007) is mostly through Absalon (web-based platform) to facilitate the interactions and to avoid the physical barrier between students and teachers. The evaluation was performed via oral examination for 30 minutes. Due to the time limit, this report is based on the evaluation of 3 students who have already examined before the actual exam week.

Course Description

Contents: The topics are: Transition-metal catalyzed reactions including cross-coupling reactions; Stereospecific aldol-additions; Chiral auxiliaries; Pericylic reactions including click-chemistry; Rearrangements; Fragmentations; Radical reactions including carbenes; Microorganisms and enzymes in synthesis; Methods for the resolution of racemic mixtures: Classical resolution, enzymatic resolution, spontaneous resolution and methods for determination of optical purity; Microfluidics in synthesis; Solid-phase supported reagents for synthesis; Case stories from the medicinal industry: What is an invention? Scalability problems.

Intended Learning Outcomes (ILOs)

Competencies: Be able to analyze a complex synthetic problem and plan a feasible synthesis. Be able to analyze scientific papers and patents dealing with synthetic problems and be able to spot inconsistent claims.

Skills: Apply the acquired knowledge on organic synthesis on a given target molecule. Be able to translate known methodologies to new problems.

Knowledge: Have an in depth knowledge of modern synthetic organic synthesis according to the content of the course.

Evaluation: 30 minutes without preparation time. The subject of the evaluation is one of the assignments with which students had already dealt. (7-point grading scale).

Workload: lectures 26 h, theory exercises 52 h, preparation 333 h, exam 1h, total: 412 h.

Outlined Methods

The investigation was designed to know how 'problem-oriented' teaching would influence Intended Learning Outcomes (ILOs) based on level of student activities. The students have diverse background (university, country, education level) and therefore, it is hard to formulate a unified direction of the lessons. It is of utmost importance to enhance ILO under any circumstances, and one of our solution is to utilize ‘problem-oriented’ teaching method. Each week, we display one target (to retrosynthesize) based on the teaching materials of the week. The teaching materials is highly related to the target molecules, and therefore, the students are well equipped with motivation and basic knowledge. The assignments will not be graded but are supposed to be handled with feedback. The selected group consisted of three international (visiting) BSc-level students, who are not familiar with current teaching setting. The course is for MSc-level students therefore, it was expected that this particular group might underperform compared to the average of students.

Challenges to face

In many cases, teaching can be tedious due to the repetitive procedures in assignment grading and teaching materials for students as well as for teachers. In this course, as shown in the course description, the students are obliged to submit their assignment bi-weekly, and each assignments are heavily associated to the topics of classroom teaching session, therefore, the classroom teaching and the assignments are more coherent. However, there are many expected challenges in the process:

Formation of the Project Groups: In the project (assignment group) the students are allowed to choose their own group, therefore, the groups are tend to be formed based on previous friendships and acquaintances. Also, there are many students who couldn’t find an adequate project group (at the current course set, we found 3 students), therefore, teachers had to interfere and force them to form a group. Eventually, it turned out to be positive, however, initial stress on the students could lead to drop-out or other personal consequences, of which should be taken care.

Collaboration Dynamics: The teachers have no information regarding the dynamics of each groups, in terms of discussion culture, work load, structure of collaboration and how they deliver the project. These may affect the learning outcome from the projects, however, it is technically difficult to follow up and manage in detail.

Formats of Feedback: The formats of feedback that has been used in this course is mainly texts in on Speed Grader. Other forms of feedback (drawings, graphics, additional literature) is also possible and it has been tried out. The feedback is mainly non-prioritized feedback as a continuous, line-by-line comments on assignments pdf. In the end, summary of teacher's feedback was given with remarks (it's ok (D), good (C), very good (B), excellent (A)). The main purpose of the given feedback is: to improve student's ability to communicate in a language in organic chemistry, where many forms of communication in industry and academia happen by drawing chemical structures and reaction mechanisms. The challenge is the deviation of quality of students, therefore, the formats of feedback was divided two main groups: for beginners and intermediate to lead both groups to competent level of organic chemists.

Effects of Feedback: the project will be delivered via online platform (Absalon) as a pdf format only and the feedback process will be performed using 'speed grader'. This web-based system allows students and teachers to interact real-time without any barriers. Given feedback can be a next topic of discussion with students using the same platform. However, some students are not used to work with online formats, therefore diminishing the effect of feedback significantly. As a teacher, it has been announced and advertised to students to work with the online formats to encourage the participation rate. Also it is found to be difficult to follow up hot much the given feedback has been used by the students since the interaction is semi-anonymous throughout the whole process. An intermediate face-to-face consultant would be desired but it was not realized many times due to the time and space restrictions.

Considering the current fixed setup at the classroom teaching and assignment, and the above-mentioned challenges, the web-based feedback process was performed as thorough as possible to maximize the outcome of the project group assignment. It is noteworthy here that the MSc-degree students in organic chemistry section are subjected to two main passages of curriculum: 1) 1-year class room teaching and 2) 1-year thesis research project (Figure 11.1, Rienecker, Jørgensen, Dolin, and Ingerslev (2015)).

Therefore, the importance of the classroom teaching in the line with the research competence of students can not be underestimated. The current group assignment and feedback process was also aimed to improve the competence of potential research activities as an individual researcher, therefore, the provided feedback includes detailed information regarding 1) grammar skills, 2) chemical structure drawing skills, 3) chemistry jargons, and 4) non-prioritized comments on minor mistakes. Although self-esteem of students can be affected by this, the teachers decided to refurbish it as much as possible at the beginning of the course period to enhance the ef-

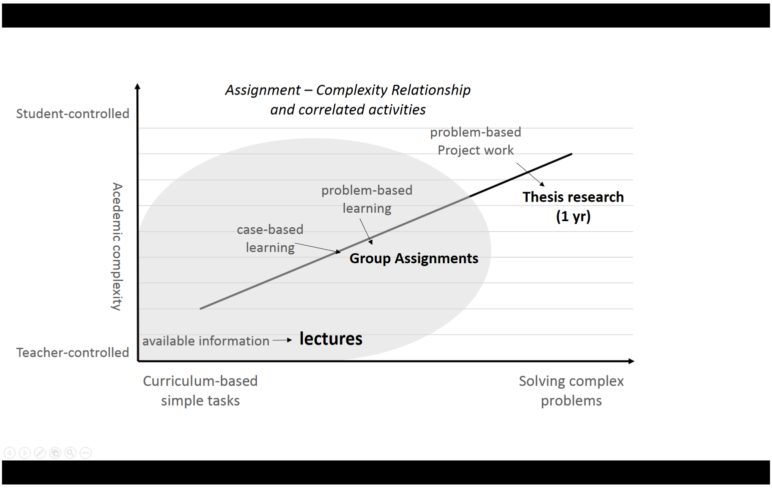

Fig. 11.1: Assignment-complexity relationship and correlated students' activities in Department of Chemistry, MSc students (Orgnic chemistry section). (Adapted from Ch 4.3 Case-based learning, L. Krogh, D. Stentoft, J. Emmersen, P. Musaeus, University teaching and learning, 2015, Samfundslitteratur)

ficiency and also to provide comfortable environment in the end of course period, where more difficult and important intended learning outcomes are placed on.

Results

As shown in Figure 11.2, the interface on Absalon is highly user-friendly and intuitive to use. Along with the assignment, multiple tasks are feasible, to add comments, highlight, strike. A plagiarism detector can be also introduced, however it was not used in this study. The interface allows users to be connected virtually with additional possibilities to add multimedia files. Although it is not attempted, it would be a good addition to upload video or audio files as feedback materials.

A designated group (international BSc students) are subjected to submit bi-weekly assignment on Absalon in the MSc-level course in the Department of Chemistry. Although the group consists of BSc students, the reports

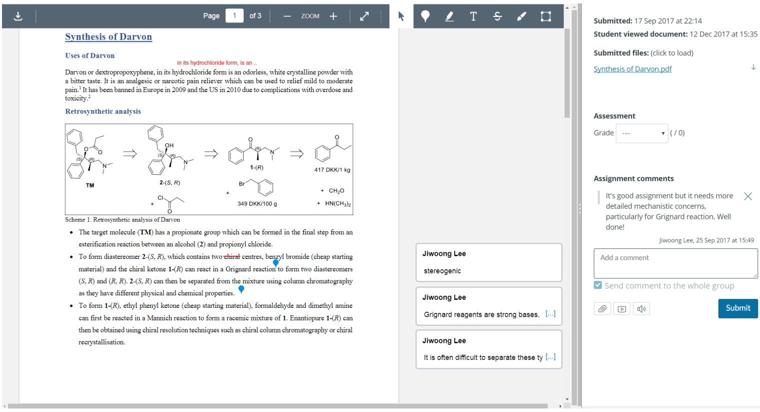

Fig. 11.2: Snapshot of Speedgrader system. A submitted assignment on the left side with line-by-line comments. The interface allows you to add graphical comments. Final remarks can be added on the right side, where further discussion with students is possible.

showed good level of chemistry knowledge in the first assignment beside minor mistakes and misunderstanding in certain key points. The summary of feedback was formulated to be very simple and positive, starting high-priority feedback: general remarks. First two assignment were in the level of B-D grades, however, the quality of report quickly increased to A-B with deep understanding in the topic, good quality of English writing in chemistry language (Schimel, 2012), and high-level of presentation skills. It was observed that much of only-positive comments gave lower quality of reports for the next assignment round. It was assertive sign that the provided feedback was used by the students and the course of learning could be changed, and controlled to improve the intended learning outcomes. One of the important ILOs is to improve creative ideas, in parallel to a traditional case in the assignments.

In the last assignment, the group presented an original idea to access a pharmaceutical active ingredient. Additionally, two students of the group received high marks (10 from 7-grading system), which showing that the majority of students of the group successfully achieved high standard of ILOs.

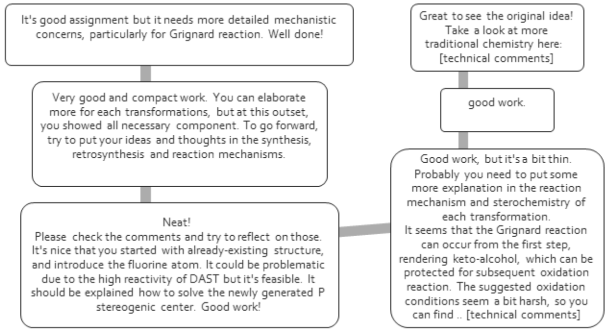

Fig. 11.3: Summarizing comments on assignments from a group. Starting from left-top, by providing formative feedback, the group achieved high standard of assignment in the end of the course (right top).

Discussion and Conclusion

Here I showed how to balance formative and summative feedback in online-based platform. This was critical to increase the student's abilities to identify the problem sets and to tackle the problem with appropriate scientific background as quick as possible with high communication opportunities with teachers. To achieve ILOs, the key challenges were set to enhance the average level of competency in solving the problem set. Also, this challenge could be associated with the learning outcomes and active learning processes, since the problem-solving process in a group is indeed an active participating process. The sample group showed high quality of reports throughout the assignments, with the help of positive and formative feedback. Line-by-line comments were helpful strategy and Absalon system greatly reduced the time spent on the grading. Also, the web-based system allows students and teachers to have less activation barrier for active participation and communication. Finally, in the case of group assignments reports it was found to be effective to use formative feedback rather than summative feedback, to enhance competency of the students while preventing diminishing self-esteem of groups of students.

The sample group successfully achieved high marks in the evaluation. It would be highly interesting expend this sample group to the whole class, with an organized feedback structure for categorized student groups. Peer-feedback system was attempted, however, it was not successful due to the lack of intense instruction from teachers at this juncture.

In conclusion, I found that online-based feedback system is beneficial to save time for grading group assignment and also to improve the competency of students in developing required skills sets in the course. Careful follow-up of a particular group of students showed that positive and formative feedback can lead to successful achievement with the ILOs, based on the final evaluation. Further studies in more detailed analysis and structured evaluation would be highly interesting, which will be performed simultaneously within my teaching and supervision.

Future Perspective (based on the peer-feedback)

The written feedback should not be an answer sheet for students while encouraging students to find the answers by themselves. It will need more fine-tuning of the structure of the formative feedback. The online-feedback platform can actually saves a significant amount of time for teachers by preventing the time-consumed by non-academic processes (printing, delivery, meetings, writing). It was suggested that the online-feedback system could be connected to laboratory courses and MSc-thesis evaluation.

After evaluation of the course period, few students argued that the online-system gave negative effect on their learning process due to the fact that the students were not familiar with it. This should be resolved by introductory lecture on Absalon in practice, probably in the very beginning of the course. Also, it should be noted that the online-feedback should be more carefully structured since those students may not follow it as much as traditional methods.

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12

Peer-instruction and drawing as student activating teaching in SAU24

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In this project report I present my experience with introducing student activities in my sau24 teaching. I describe some methods to activate students and explain how a few of these were applied to four classes taught in the neurophysiology course on the faculty of health in the fall 2017. The feedback from the students is then presented in an evaluation of the approach with regards to participation, learning, which activities the student preferred and how well they were implemented.

Background

Sau24 is an abbreviation for studenter aktiverende undervisning (student activating teaching) followed by the maximal number of students in each class. Though the purpose of this class is to activate the students, I previously did not do much to achieve this. I would give a lecture-style presentation supported by powerpoint slides, punctuated by some relatively simple questions and followed by questions on a sheet of paper in the last 20 minutes of the class. This manner of teaching was suggested to me by my co-teachers and it did not seem to disappoint the students. I now know that much more should and could be done to activate them.

The neurophysiology course is a big course in which the sau24 on the action potential is taught up to 14 times, by several different teachers, in 2x45 min classes. Since sau24 is meant to review the topics presented to the students in the lectures and in the laboratory exercises the curriculum should be familiar to the students. That presents me as a teacher with a quite uniform mass of students, though obviously some are further in learning and better prepared than others. I know from a few interviews that the students find the topic challenging. When teaching a sau24 it is my job to provide the students with an opportunity to go through the curriculum once more, so they may realize what they do not yet understand and ask questions accordingly. The purpose is to reach a deeper level of learning (Biggs & Tang, 2007), which gives better long-term retention of the learned subject (Prince 2004).

Active participation should increase learning in the students (l. Rienecker & Ingerslev, 2015). The first challenge was to decide on the appropriate methods to enhance the level of student activity. An often-proposed method in active learning is problem based learning (Prince 2004). I considered that this could be done through some real-life problems or old exam question which are likely to motivate the student participation. I then decided against it because I realized that I within my curriculum had the possibility to organize a jigsaw like discussion between the students. In such a discussion each student brings a certain theoretical perspective in to the group work doing peer-instructions (Chalmers & Fuller, 1996). To have time enough for this I had to skip introducing the subject through a complex problem. I also discarded implementation of a flipped classroom (Jensen, 2018), because its essence is preparation based teaching. Since each class is assigned to a specific team of students they could in theory be contacted with some material or information before the class. In practice the students may choose not to attend the classes assigned to them but instead go to another class. I could thus not be sure that the students in the class room had all received the instructions for preparation. To implement such a method, all sau24 teachers on this topic would have to coordinate their teaching. Finally, I considered to introduce some form of didactic game. Since it is effective in activating students and improve their learning, it would have been inspiring to do (Christiansen & Olsen, 2006), but I feared that introducing a playful approach would not go well with the high level of seriousness I had so far perceived in the students. I suspected they would be nervous they were wasting their time.

A few of my colleagues have been teaching sau24s in a very open format, letting the students define the topics of the class depending on where they felt they needed more knowledge. I decided not to follow such a student-driven approach, but instead to guide the discussions they would have. A guided discussion could be considered the intermediate between lecture-style and student-driven teaching, because the content of the teaching is inflexible, while the students are in dialogue with the teacher and each other. This I did because I did not only want participation from the students with the best understanding of the curriculum and their own abilities. These students are likely to participate in any kind of teaching and I suspect were the ones answering my questions in my previous lecture-style classes. Now my goal was to ensure that all students were active and increased their learning during the class. Since practice by doing and teaching others gives the longest retention of knowledge (Magennis & Farrell, 2005) and fits the curriculum of the sau24 well, I decided that these methods should be used to activate the student.

Implementation of drawing and peer-instructions as student activating initiatives

To ensure active learning in as many students as possible two different activities were introduced. Group work, with and without peer-instruction and working with the tasks by drawing the solution. The teaching plan is shown in Appendix 1. From the start the students were each given several pages of blank paper. They were told that answers were to be given by hand-drawn illustrations such as diagrams or dependency curves. This was done to make the students transform their theoretical knowledge in to a diagram. To do so they had to work with their knowledge in a shift in register of semiotic representations which ensures a better quality in their learning (Duval, 2006). While considering a way to represent a solution to the task the students had to construct their own knowledge (Stewart, 2012). The reproduction of knowledge in a physical format is part of a cognitivist approach because the data was externalized in the creation of diagrams, different cognitive learning styles were respected, and the students were invited to discuss with each other during the process. This approach has been shown to give a better retention of knowledge (Stewart, 2012). Additionally, some students learn better through movement than through more classical learning activities (Murphy, Gray, Straja, & Bogert, 2004). To acquaint the students with making illustrations they were given a task and told to draw an illustration in groups of three. To work together on this the students had to discuss and evaluate the solutions given by other group-members while the answer was put on paper. Such interaction in a collaborative learning has been shown to give better learning than individual learning (Prince, 2004). By asking the groups to work on an illustration together meant that not all students

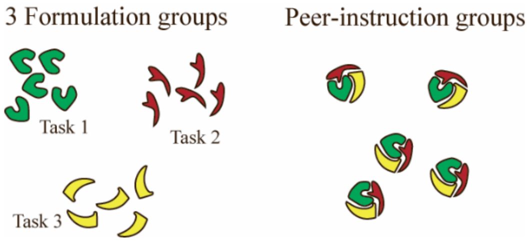

Fig. 12.1

would get to use their hands. This was of course suboptimal, but I did not expect all students to be equally prepared to use this methods from the beginning. By letting them work together on the task they would be able to gain confidence from each other, before I later would ask them to use the format independently in the peer-instructions. After they had work on the task, one of the drawn illustrations was then projected on to the whiteboard and presented by the students in the group to the class. This presentation was given in a dialogue with me to consolidate the learning of the subject. This structure of task-groupwork-evaluation of drawings was repeated once more.

I then went on to the peer-instruction activity which was done using the jigsaw method (Chalmers & Fuller, 1996). A diagram of how this method was used is shown in figure 12.1. First the students were asked to send one member to join each of three formulation groups. Each of these three large groups were told to prepare a short teaching session on the function of one or two membrane proteins. These proteins are responsible for three different mechanisms crucial for the development of an action potential. The proteins are well known to the students from the lectures and the report they write after the exercise on the action potential. The students should thus all have been well prepared for making such a small presentation. To be sure that the three formulation groups remembered all aspects of their protein functions I went to each of them and validated their considerations. After a short break the students were told to meet with the other two persons from their original groups and commence on the peer-instruction sessions. I chose to create the peer-instruction sessions because of the benefits from teaching others (Wood, 2004) and because I knew that it would be very difficult for a student not to participate under these circumstances. In the groups of three they each had the full attention of the two others for a few minutes, as they taught their part. In practice the sessions became very interactive teachings experiences because the functions of the membrane proteins are complementary in the regulation and formation of an action potential. Each of the students held a piece of the puzzle and to draw the complete illustration all membrane proteins had to be taken in to consideration. When the peer-instructions were done I quickly summarized what I believed would be the key points from the guided discussions in the groups.

Documentation

After the 2x45 minutes class I asked the students to fill in a short assessments scheme and hand it back to me before leaving the room. Through this I got feedback on how much they participated in the class, how much they felt the teaching had helped them to better understand the subject, what activities they thought were the most effective, how they liked the activities introduced to the sau24 and what they missed in the teaching. The questions are shown in Appendix 2 and 3.

Feedback from the students

The student activating initiatives ensured a high level of student participation

The main feedback I received from the assessment handouts was with regards to participation in the class. When I taught sau24 in the previous semesters I experienced that approximately 20-25 % of the students participated by asking and answering questions in interaction with me. The introduction of student activating initiatives forced a majority of students to be active. One wrote that they were more active than ordinarily in sau24 *"vi var mere aktive end normalt i sau"*. More than fifty percent stated they had been very active in the class (Table 12.1) and that they had participated both by interacting with me, drawings illustrations and/or in the peer teaching sessions.

Those who wrote that they only participated somewhat mostly report that they participated in the peer-instructions. This show how effective the peer-instruction activity was in activating students. In summation a total of 88.75% (32.5% + 56.25%) of the students were activated, which is a

Table 12.1

	Participated	Increased comprehension
Not at all or very little	11.25 %	7.5 %
Somewhat	32.5 %	26.25 %
A lot	56.25 %	61.25 %

big improvement since my previous teaching. Even though the learning activities to a high degree forced participation, more than 10 % wrote that they hardly participated at all. One student wrote that he/she needed more time to find the right answer. *"Jeg har brug for længere tid til at komme frem til et evt. korrekt svar"*. Another that he/she is shy. A third that he did not take the class with his regular team and thus were keeping a low profile. These obstacles for participation reflects the personality of the students (Entwistle, 2009) and the importance of a familiar learning atmosphere and may be hard to overcome. Other students do not reveal why they did not participate in the class, but they would probably not have been more active during a regular lecture-format class. When asked in what way todays class had assisted their comprehension of the subject almost all students choose to estimate how much they had improved their comprehension (Table 12.1). Looking at these numbers the activities appear more successful than when the level of participation is evaluated. Still it cannot be satisfactory that any students felt they had learned almost nothing even if it is few. Around half of these students remark that they are now more confused than before. I suspect this could be because the request to explain the subject to others may have revealed that they had not jet understood sufficiently to be able do so. Hopefully this will probe them to spend more time on this part of the curriculum before the exam. One of the students who remark that nothing was learned in the class explained that everything had been described previously in the lectures. This student then admits that he/she did get to practice the communication of the subject. *" Man fik ikke større forståelse da forelæsningen før havde gennemgået alt. Men man blev bedre til at formidle det"*. This effort in communicating the subject has likely given a deeper learning in the student, at least by repetition and probably also by prompting reflection (Biggs & Tang, 2007), even if the student does not acknowledge this effect. It is worth noting that the learning appears strongly associated to the level of participation in the class (Figure 12.2). A clear majority of the students with a high level of participation also felt they learned a lot. In

Table 12.2

	Peer-instructions	Making drawings
Learned most from	27.5 %	15 %
Liked best	66.25 %	31.25 %

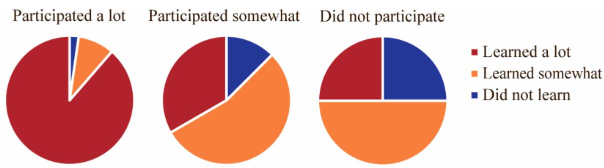

Fig. 12.2

addition, the largest proportion of students who felt they did not learn was among those who did not participate. This relationship reflects what is already known and emphasize how important it is to engage as many students as possible in an active participation in the learning.

The two student activities were not equally popular among the students

A few students objected to the use of student activities. One student gave a long defense in favor of theoretical blackboard teaching, with the main argument that it suits them better because it is the teaching format they are used to. That students may be critical of the introduction of activities is described before (l. Rienecker & Ingerslev, 2015). Other studies have found that student often appreciate interactive classroom learning (Scott, 2005). In line with this the peer-instruction activity was popular and perceived as effective (Table 12.2). Only very few were dissatisfied and then mainly because they found that too much time was spent on it. One student wrote that he/she spend a lot of time being in doubt, but luckily also felt that the confusion was dispersed in the final consolidation; *"Jeg savnede måske lidt at få det rigtige svar -der var meget tid med tvivl. Men det lykkedes til sidst i plenum"*.

The use of drawing as a tool was mainly appreciated by the students with a high level of participation. They were also among those who felt they learned the most (Figure 12.3). One such student wrote that it was

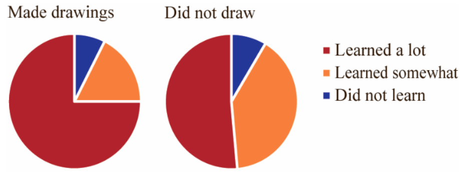

Fig. 12.3

very effective to draw, because one would then better remember the subject; “Det var vildt godt at tegne, fordi så husker man bedre”. This is in accordance with the theory, so why then was this activity not as widely appreciated as the peer-instructions? The students belong to a digitized generation and some did seem uncomfortable in using pencil and paper, but most were willing in this regard. Was the activity then too difficult? This could explain why only the best students felt they benefitted from it. Some of the illustrations I received from the students to summarize in plenum were quite rudimentary, but this is not necessary problematic. In my opinion, half the learning was made as the pencils hovered over the sheets and the students considered or debated what to draw. The most likely explanation is that this activity needed a better introduction. A more precise description of what I excepted from these drawings could have guided the students to address the task more boldly. An excess of uncertainty can hinder the students in performing the learning activity (Stewart, 2012) and a few comments from the students reveals that they did not understand the task in the beginning of the class. This I will work to improve in the next sau24 teaching.

The student activities must be implemented in alignment with the course structure

The students’ main complaint in all four classes was that too little time was spent on traditional teaching with the teacher at the catheter. These situations were of course reduced by the time spend on the active learning activities. Exactly what format of catheter teaching they requested depended on their level of preparation (Figure 12.3). The more days it had been since the class had taken the exercise related to the topic of the sau24 the more likely that the students had written the report on this exercise. Writing this report would be the optimal preparation to participate in the activities. In the two classes less prepared for the sau24 around half of the students re-

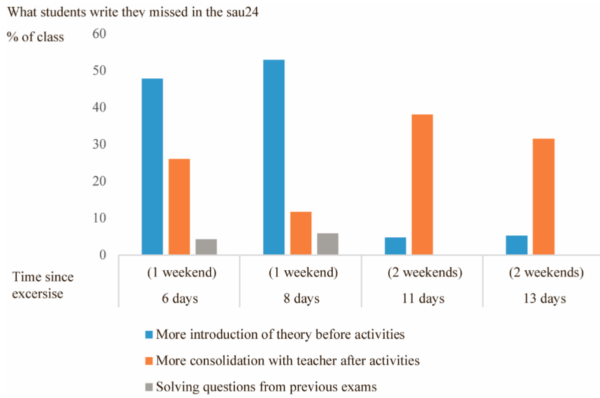

Fig. 12.4

quest more theory in an introduction from the teacher before the tasks. One of them point out that not all what they had heard at lectures was understood "Ja, vi har hørt det meste til forelæsningerne, men det betyder ikke altid at man forstår det til fulde". Meanwhile, in the two classes where most had written the report, 30-40% of the students remarked that they could have used more time consolidating with the teacher after each task. That the students ask for a better introduction and more consolidation of their learning between the activities is a relevant critique, as these steps are important to ensure an appropriate learning (Hunt, Chalmers, & Macdonald, 2012). It is thus central to Disregarding these differences in the students learning level will reduce the success of the active learning approaches. Because of the size of the course it is not possible to ensure a similar alignment of the sau24 classes to the other course activities. Thus, it is up to the teacher to get some information on how far each class has come in learning the subject. An estimation can be gained from the time since the laboratory exercises, as in figure 12.4. A much faster and more accurate approach would be to simply ask the class. Before commencing on the teaching, the proportion of students that has already written the report can be assessed from raised hands. The teacher must then be flexible in how much time is spent introducing the theory before the activities. This is in accordance with good teaching practice, as a teacher is always supposed to know the level of the students learning and adjust the level of the teaching accordingly (Hunt et al., 2012). Fortunately, even though they differed in what they required more of, all four classes appear similar with regards to student participation and learning.

Evaluation of the level of difficulty.

Some students complain that they already knew the subject. A few others objects that the tasks were too easy. One even suggest to use problem based learning to make the tasks more difficult *"Det kunne godt have været lidt sværere, måske med cases?"*. Though repetition is an aim with the sau24 classes, it is possible that my level in teaching was slightly low compared to the prior learnings of the students (Hunt et al., 2012). Since my level is based on the powerpoint show given in the previous years it is a troubling thought. My previous teaching format would not have allowed for sufficient interaction for me to acknowledge if this was the case and adjust my level accordingly. The level of teaching may on the other hand have been appropriate when the input from other students is taken in to consideration. *"God detaljegrad"*; *" vi nåede det vigtigste"*; *"Til sidst i timen synes jeg at jeg havde fået en større forståelse, men jeg synes det er et svært emne"*. Most importantly since the majority of students wrote they had a better comprehension after the class (Table 12.1), the level in teaching cannot have been all wrong. It is an important aspect to consider because the learning level in a guided discussion is somewhat inflexible. In the future I can assign more time to random questions from the students, which will give me even more feedback on what part of the subject they find difficult and help me adjust my level of teaching.

Conclusion

The purpose of my teaching is to activate the students to review what they already know. It is evident that the activities I introduced induced participation and that the students felt that especially the peer-instructions enhanced their comprehension. This is important when the goal is to make the students learn better. I no longer find it acceptable to give a lecture-style power point presentation, even though studies show that students can rate passive teaching quite favorable (l. Rienecker & Ingerslev, 2015). My teaching experiment would have been more interesting if I had chosen to give lecture-style teaching in two of the four sau24 classes and compared the evaluations from these students with the activated students. I considered to do so, but after having learned about the huge difference in the depth of learning that these two styles of teaching create (Biggs & Tang, 2007), I could not purposefully give what I knew to be bad teaching to half my students. Instead I tried to evaluate how well suited the chosen activities were. The student activating initiatives used in the fall semester of 2017 may not have been the optimal methods, nor perfectly implemented. Still it was better than the lecture-style teaching I used before. The feedback will now help me to further improve my use of student activities.

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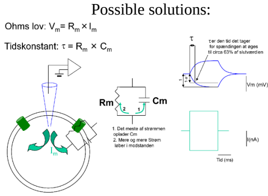
A

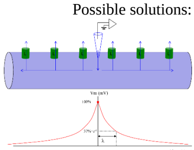
Appendix 1: Teaching plan

Introduction to the concept of drawing illustrations when working on the tasks.

First task: *Work in groups and drawing projected on whiteboard afterwards*
Illustrate the consequence of the law of Ohm on the membrane potential.
Possible solutions:



Second task: *Work in groups and drawing projected on whiteboard afterwards*
Illustrate the consequence of the length constant in the distribution of a potential.
Possible solutions:



Ask question: *Allow them to discuss with each other before consolidation in plenum.*
Which membrane proteins are crucial for the formation and development of and action potential?

Theory: Walk through the different phases of the voltage-sensitive Na^+ channel together with the students while drawing on the board.

Jigsaw peer-instructions: *Students form groups of three.*
Each of them join one of the three big formulation groups.

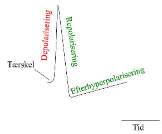
Tasks given the 3 formulation groups:

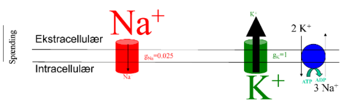
1. Illustrate the consequence of the function of the Na^+/K^+ ATPase and the K^+ leak channels.
2. Illustrate the consequence of the different phases of the voltage-sensitive Na^+ channel.
3. Illustrate the consequence of the function of voltage-sensitive K^+ channel.

Action step: *The three-student groups reform and each student is given 3 min to illustrate and explain what was debated his/hers formulation group.*

Some possible illustrations:

	Intracellulær koncentration	Ekstracellulær koncentration	Ligevægts potentiale
K^+	130 mM	4 mM	-90 mV
Na^+	10 mM	140 mM	+50mV
Cl^-	6 mM	104 mM	-75mV





Consolidation by teacher.

Final part on extracellular stimulations were done in a quick succession of simple questions and answers.

Appendix 2: Assessment scheme, Danish original

<u>SAU24 undervisning, oktober 2017</u>

1. Hvor meget deltog du i dagens undervisning? Bidrog du med et spørgsmål, en kommentar eller en tegning?

2. Hvordan hjalp dagens undervisning dig til større forståelse af aktionspotentialet?

3. Hvad synes du var bedst ved dagens undervisning?

4. Hvad savnede du i dagens undervisning?

5. Andre kommentarer:

Appendix 3: Assessment scheme, English translation

<u>Assessment scheme to be handed to the students as a final thing in my classes and filled in immediately, to be handled back upon departure:</u>

6. How much did you participate in todays class? Did you contribute with a question, a drawing, a comment?
7. In what way did todays class assist you in a better comprehension of the action potential?
8. What did you like best about today's teaching?
9. What did you miss in today's class?
10. Comments:

13

Does diversity-based group formation work for students?

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Summary. Working in group is believed to benefit students learning outcomes and develop better relationship, communication and team skills which are also important later in their professional life. However, previous research finds that these benefits may depend on the size, type and structure of the groups. I investigate whether groups formed by the teacher on the basis of academic and cultural diversity affects students perceived benefits and learning outcomes in an experiment implemented in a course "Advanced Development Economics" given for master's students at the University of Copenhagen. I find that students diversity-based exogenous group formation increases learning outcomes as measured both by perceived new things learnt, better relationship, communication and team skills as well as final grades. However, the results also highlight the need for teachers to facilitate the group process, especially at the beginning, since diversity-based groups take some time before they function properly. While these results shade light on the role of diversity-based group formation in university teaching and learning, caution is required when interpreting the results given the small sample size and context of the experiment.

Introduction

Universities are attracting increasingly diverse student populations with many international students. In order to accommodate such diversities, some scholars suggest that universities should adopt inclusive and interactive strategies, in which students' diversity is viewed as a resource for a successful teaching and learning process (Broughan & Hunt, 2012). The authors further suggest that such strategy should promote students' interaction which may increase awareness and understanding of different perspectives, better preparation for work place and greater feeling of belongingness.

One way of designing an interactive and participatory teaching and learning strategy is to enable students work in groups. These groups could be discussion groups, study groups, writing groups, feedback groups, or project groups (Christensen, 2015). Irrespective of the type of groups, working in group is expected to promote intellectual and social learning, creative problem solving, and improve relations among students by increasing trust and friendliness (Cohen & Lotan, 2014). This also ensures that students share their knowledge, skills, and experience; discuss freely on alternative ideas, solutions, and dimensions; and get feedback from their peers, which are normally quicker, more accessible, friendly-framed, and understandable. Finally, this may promote research and problem-based teaching (Brodie, 2012) and motivate students in the course and classroom (Scott, 2005; McWilliam, 2008).

Yet, the successes of group works in fostering productive teaching and learning process may depend on a number of factors (Christensen, 2015). Firstly, there is heterogeneous preference among students regarding working in groups. Some students seem to enjoy group work while others dislike it to the extent of avoiding group work-oriented courses (Christensen, 2015). Secondly, there is a lot of debate on how groups should be formed. Should groups be formed formally by the teacher (based on principles or randomly) or informally by the students on their own? What is the optimal group size for a productive group work? Should groups be homogeneous or heterogeneous? Can working in group benefit all students by allowing middle and advanced level students to seek additional academic challenges as well as helping low level students get peer support? Thus, there are a number of challenges that the teacher should be aware of in deciding on the type, size, and structure of groups.

In this project, I aim to contribute to the ongoing debate on the formation of groups. I investigate whether groups formed by the teacher on the basis of academic and cultural diversity affects students' perceived benefits and grades. I investigate this by directly implementing diversity-based group works in a master's course "Advanced Development Economics" at the University of Copenhagen. I collected a baseline (right before the groups are formed) and a follow-up (at the end of the course) data from the course participants in an online survey. I find that students perceived various benefits from working in a group of diverse academic and cultural background. They perceive that they learn new things and develop better relationship, communication and team skills. Moreover, looking at the final grades, the average grade is much higher than a similar course a year before. While higher grades could partly be attributed to differences in the composition of students between the years with and without the experiment, a particularly higher grade in the term paper, the part of the course that is most likely to be affected by the group work, points to the role of the diversity-based group formation. Students suggest that such group formation may achieve its intended benefit if teachers are involved in facilitating the group process, especially at the beginning since diversity-based groups take some time before the function properly. While these are interesting results that shade light on the role of diversity-based group formation in helping students achieve intended learning outcomes of the course, caution is required when interpreting the results given the small sample size and context of the experiment.

Case study

The course "Advanced Development Economics" is a master's course intended for students who have background in economics with a strong understanding of microeconomics and microeconometrics. The course was given in block 2 (2017-2018). The course focuses on households' and firms' behavior as well as the functioning of markets and institutions in developing countries. By the end of the course, students are expected to achieve the following in the field of development economics: 1) Comprehend and diagnose concepts and theoretical models; 2) Develop abilities to discuss, criticize, interpret, and replicate theoretical and empirical papers; and 3) Develop abilities to write a theoretical or empirical paper. To help students achieve these learning outcomes, the course has three components (lectures and small group discussions, group-based practical exercises, and individual project works). The final grade for the course is the average of grades in the oral exam and individual term papers. In order to pass the course, students must pass both parts of the exam.

Group formation

From my previous experience in teaching the course, participants are diverse with respect to academic and cultural background. The challenge is therefore to design teaching and learning activities that ensure that students actively participate and engage in class and use the diversity to their benefit. One way of ensuring this is to form groups of students with diverse background. From my experience, leaving group formation to the students results in groups of friends, which may limit students' ability to interact with fellow students that have different perspectives. Thus, I design groups myself, reflecting the diversity of the students. A group of 4 students was formed based on specific criteria (Nationality; previous experience with microeconomics and microeconometrics, development economics; and previous ability to work with STATA software). I collected information from students in order to help identify specific attributes of each student. Based on this information, participants in the course came from 9 different countries with diverse knowledge and skills.

Data

I collected information on students background (age, gender, study program, etc.); previous experience with group works (benefits, challenges, heterogeneous vs homogeneous groups, student-formed vs teacher-formed groups, etc.); and perceptions about group works (preferences, intentions, expectation, benefits, relevance, challenges, etc.) in two rounds, right before I formed the groups and at the end of my course, in an online survey. The data collected at the end of the course particularly includes information on students' experiences with the group works in my course.

To assess the relationship between diversity-based exogenous group formation and productive teaching and learning process (student satisfaction and perceived benefits), I will compare the results of the data before and after diversity-based exogenous group works. Since the sample is very small, I will only focus on correlations using descriptive statistics and students' qualitative opinions. Moreover, the final grades are used to draw learning outcomes of the group formation.

Results

10 students answered the survey in the first round and another 8 in the second round. Pooling the data, 67% of the students in the course are female. The age distribution ranges from 22-33 with a mean age of 24. The responds are from 7 different nationalities with Danish students accounting for about

28%. All the respondents answer that they have economics background and most of them are in their second-year of master's degree.

All the respondents had previous experience with group works in their university education (both Bachelor and Master's) and the average group size was 4. Figure 13.1 below show the distribution of number of group works that responds had experienced in their previous university education.

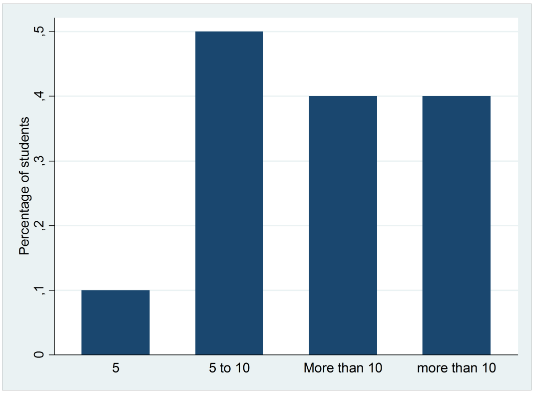

Fig. 13.1: Number of groups works students experience in their previous university education

From the figure, it is clear that students have significant experience with working in groups in their previous university education.

Table 13.1 below summarizes students experience and perceived benefits of working in groups. In the survey, students are asked if they agree to a number of statements ("1: I do not agree/No not at all" to 5: "I totally agree/Yes absolutely and "1: Never" to 5: "Always"). The results show that students had positive experience with previous group works. Most agreed with the various benefits (learn new thing, better outcome, good relationships, and team skills) of working in groups. While students had experience with groups formed by teachers, most of them were not diversity-based. An interesting result is that students like diverse groups and appreciate the role of the teacher in facilitating the group process, but they prefer more if they form their own groups. Yet, they acknowledged that most of the groups formed by students are less diverse. This is a very interesting dilemma. On the one hand students believe that groups with diverse cultural and academic background are more beneficial in terms of learning outcomes. On the other hand, they want to form their own groups which ended up becoming less-diverse. There could be a number of reasons for this dilemma. First, although students perceived an advantage in diversity-based exogenous groups the transaction costs may be very high to justify these benefits. These costs may be in the form of communication problem and free riding by some students. Second, it could be that students benefit from process based learning outcomes such as better communication and team work skills, but not in terms of actual learning outcomes (e.g., as proxied by final grades). This may suggest that teachers should pay attention to the group process. Teachers could facilitate the group process mitigating communication problems and misunderstanding as well as direct groups towards achieving both process based and final learning outcomes. For instance, teachers could encourage groups to use Absalon in facilitating group works to which the teacher could monitor and intervene whenever it is necessary.

Table 13.1: Experience, benefits, and challenges of working in groups

Questions	N	mean	sd	min	max
I have had very positive experiences with group work	10	3,20	0,79	2	4
Benefits of group works					
Better learning outcomes	10	3,30	1,06	2	5
Lean new things	10	3,70	0,95	2	5
Develop good relationships	10	3,50	0,85	2	4
Develop team skills	10	3,60	0,70	2	4
Formation of groups					
Student formed groups are less diverse	10	3,60	1,35	1	5
Teacher should facilitate group process	10	3,70	0,82	2	5
I like groups of diverse groups	10	3,50	0,85	2	5
I prefer student-formed groups	10	3,60	0,97	2	5
I like diversity-based exogenous group formation	10	3,00	1,25	1	5
Experience with diversity-based exogenous group formation					
In previous group works, the teacher formed groups	10	3,00	1,15	2	5
Previous groups follow diversity-based exogenous group formation	10	2,50	1,08	1	4

The results from the second round survey, in which I ask them specifically about the group process employed in the course “Advanced Development Economics”, are presented in Table 13.2 below. These results are in line with those in Table 13.1 that working in groups help learn new things, develop team skills and relationships. However, unlike in Table 13.1, students have now a clear preference for diversity-based exogenous group formation.

Table 13.2: Perceptions and benefits of diversity-based exogenous group formation in the course "Advanced Development Economics"

Questions	N	mean	sd	min	max
I have had very positive experiences with group work	8	3,38	0,92	2	5
Perceived benefits					
Lean new things	8	3,38	0,74	2	4
Develop good relationships	8	3,75	0,46	3	4
Develop team skills	8	3,13	0,64	2	4
Diversity-based exogenous group formation					
I like that the group was a mix of diverse academic and cultural background	8	3,63	1,41	2	5
I would have preferred a group formed by the students themselves	8	2,88	1,81	1	5

Students were also asked to give opinion regarding benefits and challenges of working in groups. Communication problems (attitude and accent), free riding, hyper-perfectionist students, diverse working styles and academic background are mentioned as challenges of working in group.

Students specifically mentioned diverse opinions, opportunity to learn from each other, feeling of "not excluded", and a better integrated class room as benefits of working in a group composed of diverse academic and cultural background. For instance, one respondent wrote *"Get a more differentiated perspective on the topic, exchange experience and understand how other governments and institutions work."*

However, students also mentioned that diversity-based exogenously formed groups require more time before they function properly, particularly given the diversity in the level of education and communication problems. One student pointed that *"Schedule is a big issue when we have block system, since it's very hard to find time out side of class to work together (if necessary). Academic level is also a problem if people have different levels of experience working in stata, the topics etc. This is also a prob-*

lem for people with less experience since it can be difficult to "catch up" and be a good group member when the others might initially know much more than you, making your learning outcome less". This is in line with the idea that teachers could play an important role, potential by employing technology (e.g., Absalon), in facilitating and monitoring functioning of diversity-based group works. Finally, the average grade for the course is found to be higher compared to the same course in the previous year. It is true that differences in the composition of student could play a role in the average grade difference. For instance, if this year's participants have better background on microeconomics and mircoeconometrics, which are the pre-requests of the course, the average grade could be higher. While it is difficult to disentangle the effect of the group work formation on the final grade from student composition, a particularly higher grade in the term paper points to the role of the group formation. This is particularly because the term paper is the part of the course that is most likely to be affected by the group work. Although it has to be written individually, the activities in the group works are directly linked to the requirements in the term paper.

Conclusion

Working in group can help students achieve the intended learning outcomes a course (Astin et al., 1993; Tinto, 1987). It can help students develop communication abilities, relationships and team skills which are also important later in professional life (Mannix & Neale, 2005; Caruso & Williams Woolley, 2008). However, working in group has its own challenges, such as communication issues, that might negatively influence teaching and learning process. The type, size, and structure of groups also seem to have an effect on whether students reap the mentioned benefits.

In this paper, I investigate whether the way groups are formed (by students themselves or formed by the teacher on the basis of diversity) has an effect on students' experience and perceived benefits. I conducted a small experiment by implementing diversity-based exogenous group formation in my course "Advanced Development Economics" which was given to master's students. I collected a baseline data right before the groups are formed and a follow-up data at the end of the course in an online survey. I find that student like working in groups of diverse academic and cultural background formed by the teacher. Participants mentioned that working in group helped them learn new things, develop better relationship, communication and team skills. Moreover, the average grade (a proxy for better learning outcomes) is higher as compared to the average grade of the course in the previous year. However, students mentioned that such groups need time before they function properly and this may be a problem in block system. They suggest that this could be improved if the teacher facilitates the group process, especially at the beginning. This call for the role of the teacher in facilitating and monitoring group process and activities, for instance, using Absalon.

While the results from this project shade light on the role of diversity-based group formation, it is very difficult to conclude based on such small sample. Moreover, this group formation may be course/context dependent. Thus, future studies that include a larger representative sample are needed before arriving at conclusion.

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14

Case studies and digital response systems in science courses for master students: Are we encouraging valuable discussions?

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Introduction

This article reviews the learnt experiences from the implementation of a Case Study and two student response systems in a MSc. lecture that originally had a teacher-based style. The lecture was selected from the **'Fruit and Berry Crop Physiology and Quality'** (FBCPQ) , a 7.5 ECTS course in which I have been teaching for some years. This Course is part of the MSc Education Program in Agriculture, under the sub specialization Plant Sciences. The cooperation partners in this Course are the Copenhagen University Fruit Genbank: the Pometum and a number of fruit companies and educational institutions in Denmark and abroad.

The lectures in this course take place on Tuesdays and Thursdays. Each year the course attracts students from different nationalities and agro/food-related backgrounds such as: Natural Resources, Agriculture, Horticulture, Plant Science, Agrobiology or Environmental Science from Danish, Nordic or international universities, Agricultural and Environmental Management from Danish Business Academies. Students with Biology, Geography, Geoinformatics and Biotechnology backgrounds are also admitted. For international applicants, there is a requirement of higher English sufficiency exam.

The 'FBCQP' course has a combination of classroom lectures and practical exercises /excursions. The individual lectures in which I have been teaching cover Fruit production and Juice quality aspects with focus on quantitative and qualitative techniques for Quality Control, in which both, theory and practical exercises are addressed. The theoretical lectures take place on Tuesday mornings, whereas one of the practical parts is scheduled for one entire afternoon (usually a Thursday) in the University laboratories and facilities, after the theory presented on tuesday. The module contents have been organized in this manner to balance the interaction classroom vs. laboratory for students and teachers, that otherwise would have to spend entire days in the classrooms. Besides this, some of the topics are presented by external teachers, PhD students, Postdocs or guest lecturers, who participate in the course one or two times.

The Problem

Although the course has a reasonable combination of theoretical presentations, excursions and lab exercises, the theoretical lectures –teacher-centered, are sometimes exhausting for teachers and students.

On Tuesdays, students participate in oral lectures from 8:30 to 12.10. Each subject is presented during 45 -50 minutes, with 10 minutes pauses in-between. It means that there are 3-4 topics presented during the morning. This format allows for improvements in the activities and time allocation used during the lectures.

Under these premises I investigated whether including case studies in teacher-based lectures will promote a more active participation and learning satisfaction among the students taking the FBCQP course. Therefore, the objectives of the study were the following:

- Review complex scientific and old dated terminology/contents in the teaching material, and introduce case studies, to improve students understanding of key concepts and provide them with better preparation to the practical exercises connected to the lectures.
- Engage students during the lectures with the help of: infographics, interactive tools (on-line quizes, intuitive colaboration tools)
- Discuss with peer teachers/evaluators on any additional pedagogical elements that can be improved or implemented

Theoretical Background

The student participation dynamics in University classrooms change constantly. Students are increasingly being exposed to a huge range of digital tools to complement their learning. Modern technology however, can also become a potential procrastination partner for them (Anshari, Almunawar, Shahrill, Wicaksono, & Huda, 2017; Furst, Evans, & Roderick, 2017). On the other hand, the new generation of teachers joining the academia, have an additional challenge. With little pedagogical experience and time, they take part on lectures that traditionally use a monolog approach and have to quickly adapt to new teaching material or pedagogical tools to provide quality education.

Lectures at Universities have been traditionally based on the teacher's academic knowledge rather than the student learning (Rienecker, Jørgensen, Dolin, & Ingerslev, 2015). The higher demand for quality teaching and reduction of teaching resources, is moving this trend towards the use of alternative learning tools in classrooms (Zainuddin & Halili, 2016). Clickers, quizzes, or different response systems encourage student participation and thus the interaction teacher-student . At the Science educational programs in Copenhagen University, these interactions are being ranked high or very positive on the student's preferences and Course evaluation surveys.

However, such digital solutions cannot ensure assimilation of contents on their own without valuable teaching material behind it. Today, such material has to deliver theoretical knowledge and reflections from situations in the 'real world' to be considered 'high quality' by the students.

Case-based learning

Case Studies and group discussions are excellent solutions for ensuring that a lecture is not passed on into a mere transferal of notes and bring theoretical component in practice (Rienecker et al., 2015). Apart from the known advantages such as encouraging own understanding, improving communicational skills, create collaboration communities, strengthen connections, remove misunderstandings, increased effort, reduce study time, provide insight to collaboration, formulate academic arguments, etc., group work can also introduce the following challenges: power struggles, personal positioning, stress- or the like. These issues require attention and well planning ahead from the teachers before, during and after the lecture (Bonney, 2015). Evidence shows that groups of 3 to 5 members work best under the University settings. Furthermore, teachers should ensure that student expectations and requirements are covered in the group work. In practice little time, highly diverse student groups, or unexperienced teachers, make the success of the implementation of case studies and group discussions challenging.

Another challenge that comes along with the case-study teaching format is that the teacher *assumes* the facilitator role. It means that apart from selecting a 'good case' material and carefully adapting it to the current one, he must have other abilities such as: start discussions if they do not arise, show active listening to what is and also to what is not articulated or when necessary, the teacher should let the students lead the learning process. Therefore, the success of case-based learning will depend on student participation and engagement to a greater extent than in other teaching activities (Rienecker et al., 2015).

The case-study method will further allow students to keep focused on the learning and the academic content, by which students can develop metacognitive and reflective academic competences.

My approach

The FBCPQ Master course received 5 students. All of them had different backgrounds, and the same nationality (Denmark).

Two subjects were selected for this project: 'Fruit Quality evaluation' and the practical exercise that is a continuation of the lecture: 'Fruit thinning, sorting and Fruit Quality'. The first oral lecture included 2 digital response systems (*Socrative* and *Padlet*) and a case study. *Padlet* is an interactive way to share opinions online and the *Socrative* assessment tool was used to receive immediate feedback of my teaching at the end of the lecture. The second lecture focused mostly on a practical exercise that students performed out in the apple orchard (the Pometum) and at the laboratory. The discussion that followed up the case study was included at the beginning of the practical exercise in the second teaching day. In addition to this, three senior lecturers were interviewed to provide additional insight on good quality discussions in Science Courses for MSc students. I assigned 25 minutes for the oral presentation and 15 minutes for the introduction and realization of the case study. The contents of the oral presentation were reviewed and reduced. Where possible, the text of the slides for the oral presentation was summarized or replaced with info-graphics .The case study 'One Bad Apple' (Appendix B), that originally addressed a statistic problem developed by H. (n.d.), was reviewed, edited and adapted to my course materials content. It was presented in the last 15 minutes of the lecture, so that students had the possibility of solving it in groups and deliver their answers at the end of the lecture. A short evaluation quiz was finally presented during the last 2 minutes of the exercise.

At the lecture, I assessed the background of the students, announced the basic rules for my teaching (regarding interruptions, questions, ILO's) and proceeded with the presentation and explanations of the slides that I prepared for the lecture, including the digital tools. There were no questions asked at the end of the oral presentation and the timing worked well. In respect to the use of *Padlet* to collect their reflection of the case work, a few students wrote very short comments to the questions. However, the students took the case study positively and participated actively with the evaluation quiz that was delivered at the end of the lecture (Appendix A). The answers of the case-study were re-visited at the beginning of the practical lecture, that took place in Thursday of the same week. For this I used the first 10 minutes for the discussion of the results in plenum. I tried to encourage student participation by asking them to elaborate more on their reflections and tried to dig more into the main questions of the case study. As student responses and new questions came along, I elaborated more on the different concepts of the questions and finally I did a wrap up by linking the take home messages to the practical exercise that they performed in groups afterwards.

My perception is that for non-experienced teachers, subtle pedagogic details in the start of the discussion can make big differences in a case-based lecture setup, especially when the contact with the students is limited, the teacher had little instruction before the teaching or if the communication between the different teachers that participate in the same Course and the course leader is not optimal. For the case study in this project, I chose questions that encouraged students' reflections on concepts that were part of the ILO's in my oral lecture in 'Fruit Quality' (fruit maturity, quality control methods).

Although the case study exercise did sparkled the curiosity among the students and provided them with additional information to the concepts in Fruit Quality Determinations that were not part of the lecture, I investigated further about how I could have approached the discussion differently, and if so, what difference would it have made to the outcomes of the exercise, both for the students and for me. The opinion of three very experienced lecturers of Life Sciences, all of them with 10+ years of teaching experience in Science Courses for Bachelors and Master students and with high popularity among students provided valuable insight about quality discussions for non-experienced teachers.

Jens Streibig, Emeritus professor with 40 years of experience in teaching the subjects Weed, Pesticide and Crop Sciences, said that he used a mix of theory and practical exercises in his statistic courses. For him, including mid-lecture evaluations after 20 minutes oral presentations worked well to evaluate the level of understanding of the concepts that he explained during the lecture. Students had only 10 minutes to solve the statistical problem proposed. In this context, good discussions arose irrespective of the students had solved the exercise or not. The students who had solved the problems on their own were the ones who got the most out of the teaching material. ‘Controversial students can be difficult to control but one has to be tough there’, he said. Listening to the opinions and questions from students is also a good idea to adjust the terms used in the lecture and hopefully reach their different learning needs, ‘sometimes what is obvious for me is not so for the students, so I had to change my presentation over time’. He recommends using provocation (what upsets students) and examples that connect the concepts used with the real world to engage students and startup good discussions.

For Eva Ronsenqvist, lecturer with 10-year teaching experience and course responsible of different MSc Courses, using data from her own research to discuss phenomena (physics) and theories behind it has given good results. At her lectures, students are given a scientific article related to the concepts they have to learn and in groups they discuss what they have understood about it. She defines an ideal discussion during a lecture as having a group of students discussing a specific topic, engaging in conversation and the teacher acting as an observer only- ’ This rarely happens’. In her opinion, activities that can initiate good discussions include: telling students that they are welcome to interrupt the teacher’s oral presentation so they don’t get lost, introduce an unknown practical application and excursions to real research environments where students perform an exercise. One challenge in this type of setup is to get the Chinese students to talk, ‘they participate under command and that takes an extra effort from the teachers’- she highlights. In the *Climate Management Course*, the teacher has to be knowledgeable about the different contents and the lab work do require someone who is an expert into the specifics and the lectures have to be integrated with each other. Therefore this course is only thought by senior teachers.

Controversial matters are dealt with honest communication, explaining for example ‘ the reasons why you have an opinion and acknowledge it based in competent background, facts’. If the presentations /discussions in plenum are good, Eva does not interrupt them. Discussions should not be longer than 15 minutes and the wrap up at the end is no longer than 2 minutes. Eva has been responsible of the following MSc.Courses at Copenhagen University : Climate control in greenhouses, Gas exchange and chlorophyll fluorescence, Stress physiology, Climate Management in Plant Production and Research and Experimental Plant Science.

Vibeke Langer, shared her reflections from her 20 years teaching experience. She has been course coordinator of the following MSc Courses: *European Farm and Food Systems, Applied Ecology* and *Organic Agriculture* at the Faculty of Science, Copenhagen University. She considers that 'discussion' is a rare term to use. It can be many things 'joint making sense', 'conversation where participants are informed, enter with an open mind and are willing to listen and adjust'. For her the ideal discussion should not start with general questions such as 'what do you think of. . . .' , it should rather address the learning messages for students. 'The students leaving my classroom are wiser, and that means that they have to prepare before the class to be able to engage in meaningful discussions'. A proper discussion setup would be organizing the students into small discussion groups first, either guided or more free, then followed by a discussion in plenum in some way. To reach this, it is crucial to prepare very well in advance, be ambitious and do not limit the conversations to right and wrong answers. A challenge for non-experienced teachers that she points out is perhaps trying to cover too much. 'You should start with the little and stick to it'. 'Think about what is the end through, don't focus on closed areas and send signals of verbal ambition. A good way to deal with students with different needs is to identify them, by for example, asking the students to present a specific problem from their own countries. This exercise will make the needs, background and styles visible and explicit'. Controversial matters are dealt by relating topics to values and make them seeable, and by structuring discussion according to the end message. This also means that the timing must be also planned in extreme detail.

Discussion, reflections and conclusions

Active classrooms today are highly engaging, entertaining and deliver valuable knowledge of high quality that can be used in practice. At least that is the expectation of most Science students nowadays and the University educational programs try to satisfy these demands. In the Science Faculty, Copenhagen University, teaching has a high degree of discussion, independence and self-reflection of the lecture contents. With the high diversity of students that we receive each year and the never ending teaching options available in the digital world, planning teaching sessions require more and more time to be able to cope up to the requirements of an education system which is in continuous development and is highly competitive. The exercise presented in this project illustrates how adding new elements in a teacher-based lecture can add value and potentially make a lecture more engaging. However, I think that to fully reach this goal the teacher should be competent to be able to do the transition from authority to facilitator. From what the senior teachers expressed in the interviews, this facilitator role requires years of practice and exposure to different student groups and conversational situations. New coming teachers can highly benefit from the support of seniors during the design, planning, implementation and adjustment of their teaching material. One way of doing it could be through a forum of discussion of the numerous situations that educators face in their teaching practice. This would enhance the quality of discussions in the classrooms. For Universities that have the dual approach: teaching and researching, additional assistance in teaching becomes absolutely necessary to be able to deliver the same or even improved quality in all the educational programs. The interviews also made it clear that contrary to what many young talents may think, good discussions in class does not 'just' happen, and yet although contents of a lecture are prepared in advance, high quality discussions require an extra effort from the teacher side. The teacher must be well prepared, attentive, know what to do if group conflicts arise, be persuasive and know how to properly improvise to maintain a nice teaching environment. Students on the other side, need to receive a common understanding and ground rules of the conversations that take place during the discussion, according to the topic, to feel comfortable enough to dare sharing their opinions in plenum (Brookfield & Preskill, 2012). This friendly environment is the responsibility of the teacher in charge. The art of showing students what a respectful and democratic discussion looks like, what they can get out of it so that they take it seriously, requires experience and dedication . Aspects around this may include: Recognizing the value of silence, of well framed questions, of democratic agreements, alternative perspectives, etc.

At the Master educational level, this also means that students must be well prepared before entering the class. This adds an extra value to the whole class and leads to fruitful outcomes for teachers and students. In practice it may be that not all the senior staff would be willing to participate in training initiatives for the new generation of teachers.

In this context, digital tools are a fantastic way of engaging students without having to persuade them too much, because they can already use these devices. Using different tools during the lecture is enjoyable for both the teacher and students. I personally noticed a more engaging atmosphere after including the different digital tools in my lecture. Students are very familiar with smartphones and computers. For this exercise they preferred to answer the questions using their telephones. In bigger groups it would be worthy preparing additional material for reading and structure a more detailed conversation on topics that can stimulate their curiosity.

The case exercise presented in this project, would benefit from including other optics or literature review about the different implications for the juice/cider industry, to have a little more in-depth discussions. In general I think that the quality of discussions in Science Courses would greatly benefit from a joint Seniors and Junior's workshop where best teaching practices can be reviewed and discussed.

A limiting factor to introducing such tools in the different courses is the time and human resources available to do this job. This is a dilemma that Universities should take seriously to be able to shorten the gap between senior and new teaching staff, to keep up with the quality of education that the students expect to receive.

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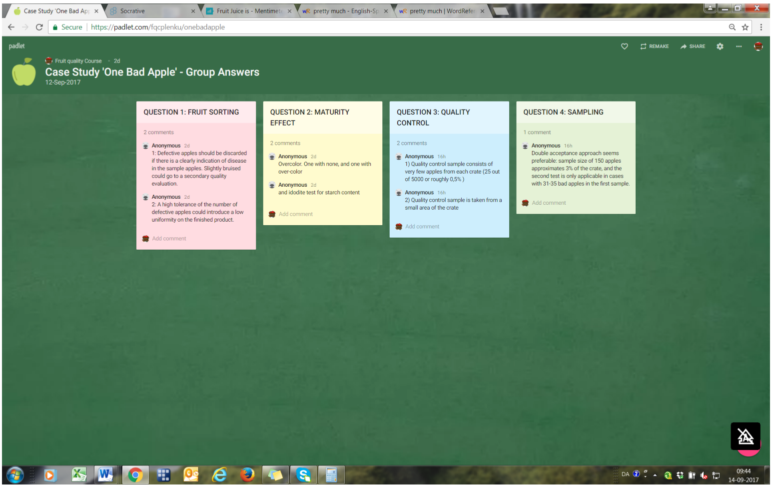
A Padlet Responses Group Work – Case Study



B Case Study

CASE STUDY

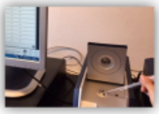
One Bad Apple:

Designing Harvest Plans for Better Food Quality

ValleyTree Orchards, a large beverage company, has been working on improving the taste of their apple cider. Customers keep complaining that the taste of the cider is variable: one bottle tastes great, the next bottle they buy tastes sour or too sweet or stale. The research and development team can produce a bench-scale product that has the same flavor from batch to batch. So can the pilot-scale production team.The problem seems to be with the full-scale production line.

The quality assurance (QA) team has reviewed the quality control data of products tested before the product is shipped and did not see anything unusual. Sensory evaluation, viscosity, and microbial counts are all within acceptable ranges for all samples that have been shipped out.

One quality control technician mentions that some of the samples they test tasted a little different, but she admits that she's been tasting cider for years and might be more sensitive than the average consumer. Samples that taste different don't show up on particular days and don't seem to be correlated to any of the other quality control (QC) data collected.



The QA team has also gone over the process with several engineers and can't find anything that would cause variations in flavor. Cleaning and maintenance are performed as scheduled. Without any luck in finding any root causes in the process or the QC data, a frustrated member of the QA team, takes a look at the raw ingredients coming in. He watches a shipment of apples being received.

The apples are shipped in large crates, about a meter high, and a meter and a half wide and long. As each crate comes in, they are checked for quality. The QA team member watches as a worker collects about two dozen apples from the side of a crate that is closest to the worker. She takes them over to a nearby table, checks each one quickly, then puts the apples back in the crate.Curious, the QA team member walks over to the worker and asks her about the receiving process.

She explains that each crate needs to be checked before being accepted. Depending on the size of the apple, each crate will contain 4500–7500 apples. Too many bruised, punctured, broken, wormy or improperly matured apples mean that the crate is bad. If more than 20% of apples are flawed in this manner, the crate shouldn't be accepted. So she's been looking at two dozen apples per crate and rejecting crates with more than 5 bad apples in that set of two dozen. The QA team member asks how long she's been working. She's been at the company for several months. However, the customer complaints have only been showing up for the past 6 weeks.

When looking at the records of suppliers, he finds out that two farms have recently joined the list just few months ago. One of them is replacing one of their biggest suppliers. The QA team member may have found another dead end. Or maybe not.

Questions

1. FRUIT SORTING: Commercial apples are usually carefully selected at harvest. Here, damaged and wormy apples are removed. However for juice making purposes, whatever fruit available is used, normally those not meeting the standards, thus defective apples can be included in the lot that enters the process.
   - **What should be done with the defective apples?**
   - **Why is a good idea to reject shipments of apples that have a high number of defective apples?**
   - **Would maturity affect juice quality if there is considerable variation? how?**

2. MATURITY EFFECT. The QA team member wish to find out whether the variation in quality reported is coming from their suppliers, one approach is to test the effect of apples with different maturities in the fruit juice sensory quality. **Suggest a methodology to select 2 maturity groups from one cultivar, to make 2 types of juice in this experiment.**

3. QUALITY CONTROL: **Do you see anything wrong with the way the worker is checking the incoming crates of apples? Explain your answer.**

4. SAMPLING: Several members of the QA team are worried that the sampling plan is too strict. Traditionally they have been using a 'single acceptance' plan, now they want to try a 'double acceptance' plan. These sampling schemes consist on the following:

   Single acceptance approach: Under this plan, 150 apples per crate will be checked. The sample will be accepted if no more than 30 apples have bruises, punctures, or breaks and the sample will be rejected if the sample has more than 35 apples with bruises, punctures, or breaks).
   Double acceptance approach: If the sample needs to be tested again, 20 more apples will be tested. If the total number of apples with defects from both the first and second samples is greater than 35, the lot is rejected. Otherwise, it is accepted.

   Which sampling plan do you think is better to use, the single acceptance or the double acceptance? Or would you choose a different sampling plan? Explain your answer.

Part V

Course redesign to improve congruence

15

Partial re-designing of the quantum information course: Adapting to advances in the field

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Problem description

The *Quantum Information* course offered to the masters and PhD students at the Niels Bohr institute until 2016, was designed approximately ten years back. It was created to educate students in the basics of quantum information sciences. The course covers a wide variety of topics with a good balance between theoretical concepts and applications. However, over the past decade the field of quantum information have advanced substantially, and has become quite interdisciplinary. Furthermore, newer physical systems and technology has been developed to implement information processing at atomic levels. As such updating the course with some of the latest material and concepts is warranted. It is also necessary, to maintain the quality of the course at a standard, comparable to that offered in other top universities in Europe and North America. As such, in addition to including new material one needs to also re-define the intended learning outcomes (ILOs) of the course, which are even, not well aligned to the present version of the course .

Course structure

The course *NFYK13005U Quantum Information* is an elective course of 7.5 ECTS points offered to masters students and beginning PhDs. The course aims at teaching students how to implement information processing (communication, computation, measurements, etc.) more efficiently by exploiting the principals of quantum mechanics. Generally, there are 20-25 students in the course among which about a fourth, are pursuing PhDs in topics related to quantum information science. Quantum mechanics and advanced quantum mechanics is a pre-requisite to this course. It is quite helpful to have some exposure to laser physics and/or quantum optics though not necessary.

Intended learning outcomes (ILOs)

The course description (kurser.ku.dk) breaks the ILOs of the course into three broad areas, skills, knowledge, and competences (see Appendix A). In general the ILOs are well laid but not necessarily aligned to the course. For example, according to the skill sets, the students are supposed to be able to discuss how decoherence and imperfection appears. In practise though the course lacks substantially in this parts of the skill set. Furthermore, when we introduce new systems and technological aspects of the field, the ILO will become even less aligned. The competence aspect of the course to some extent is sound. Finally, as for knowledge, the course lacks in providing the students with it in several areas. I will discuss this in detail later in section 3. A substantial part of this misalignment comes from the fact that the course has not been updated to reflect the later developments in the subject.

Learning activities and instructor's responsibility

The course has two instructors, with me being one of them. The workload is equally divided among the course instructors. A typical week involves 3 (4 x 0.75) Hrs of lectures, 3 (4 x 0.75) Hrs of exercise solving sessions (given about a week in advanced to the students who are supposed to have tried to solve it already) guided by the instructors, and 1.5 (2 x 0.75) Hrs of journal paper discussion (papers are also given to students one week in advance). The exercises are typically made at a level 1 of pedagogical teaching (Herron, 1971; Tamir, 1989). The weekly bulletin in course homepage gives brief summary of the different teaching learning activities that will be undertaken in that week, and contains links to course material, exercises and journal articles. This is typically uploaded one week in advance.

Assessment

Assessment for the course is done by an oral exam of 0.5 Hr by instructor and one censor (internal). There is no feedback on exercises (except during the solving sessions) and nothing from the exercises or article reading and discussion directly contribute towards the evaluation of the final grade for the course.

Constructive alignment

I will discuss the issues with the course in terms of the constructive alignment model put forward by Bigg's (Rienecker, Jørgensen, Dolin, & Ingerslev, 2015). This model suggest that for optimal student learning the ILOs, should be aligned with the learning activities, and the assessment. As pointed our before, there are issues with the ILO's. To discuss this issues I will also follow two perspectives, namely the students perspective and the colleague perspective. Before going into further discussions, I should mention that the ILOs were written before I had any pedagogical training and any knowledge of its importance. The course ILOs were just a follow up from an old version, that my senior colleague who used to teach this course alone had.

Students perspective: The ILOs for the course is not optimal. Let me now discuss the primary reasons behind this judgement. I believe we have way too much information in the ILOs which to certain extent is a bit vague also. For example, we write, "discuss how decoherence and imperfections appear and influence experiments and know how to describe it in terms of the density matrix". In reality we actually only partially follow this in class. It is actually quite hard to discuss this topic without going into details. Thus, certain part of it also becomes vague. I have observed while teaching how much students struggle to grasp this concept.

The ILOs to certain extent speak about student building some understanding about experimental implementation. It is impossible to achieve this as both of us (the instructors of this course) are theoretician. Even though we discuss some experimental papers as a part of the course the student not necessarily build up the required expertise from this. The course is heavily biased, as far as choice of physical systems for implementation of quantum information protocols are concerned. We have completely ignored the solid state quantum computing and information stuff. This currently account for almost 40% of the field. The ILOs do not acknowledge this fact. It also unnecessarily favours students with quantum optics background, when it is not a requirement for the course.

Finally, we talk about students learning quantum cryptography and error corrections, when in practise we can hardly accommodate these topics due to time constraints. We end up giving students some flavour of these topics which by no mean can help them gain expertise. I will however say that the learning activities that we employ for this course in the form of lectures, exercises and journal article discussion sessions are to some extent adequate and well linked to each other. They are done in a way so that the concept introduced in the class becomes clearer while doing the exercise. Furthermore, the students get the feel of the state of art in the field by reading some latest journal article.

As for assessment, we have an oral exam for about 30 mins for each student where we check for whether they acquired the expected skills or not. My observation is that, this assessment scheme is suitable to the students who have previous exposure to this kind of a examination scheme. In general it proves to be very challenging to students (typically internationals) who have never before participated in a similar exam. Hence in its current form the assessment is biased towards certain groups of students.

Colleague perspective: There are two instructors for the quantum information course, I am accompanied by another senior colleague. He was the one who was teaching this course all by himself before and had created the ILOs for the course. Currently we share jointly the responsibility of the course with the total workload equally shared. However, for the material of the course like lectures and exercises we use a lot of the stuff that he had created earlier. During the course, we have some meetings with an objective to build coherence in the course. However, there are certain key issues regarding this that I will discuss next.

My colleague is a bit conservative regarding making any drastic change to the course. From several years of teaching experience, he judges the course to be well tuned. Even though he acknowledges the problems with ILOs but seems to prefer little change at a time. Having much less teaching experience, I am also not fully confident in its outcome and hence also find it is difficult to convince him in these regards.

The course material and the exercises are tuned to his way of teaching which is not necessarily same as mine. This create some issues for me when I am trying to validate certain task. For example, I become unsure of the boundaries to which we go, while discussing a question. Finally, my colleague is an awesome teacher and have vast (more than 10 years) pedagogical experience, as such I find it difficult to match his insight on student learning experience. This then concerns me, as to whether students are getting the required and relevant understanding on the topics I am teaching.

Proposed solutions

It is evident from the above analysis that there are several areas of improvement to create better constructive alignment for the course. To start with, one needs to address the issues in the ILOs. In brief we itemize the issues with the course and their possible solutions below.

1. Need to write a new ILO which should be more concise and a truthful reflection of what students should expect to achieve from the course.
2. Introduce new course material for solid state quantum computing and decoherence. This topics are crucial for implementation of quantum information protocols and hence needs more weightage than currently given.
3. Modify assessment method to better judge the skill acquired by student in the course. Since the course does not have huge enrolment, a possible solution can be to introduce a writing assignment like a short report on topics covered in the course in addition to exam and put 25-30% weightage of the final grade on this.
4. Build better synergy between the instructors by having in-depth discussion about what will be covered and how will it be done.
5. The ownership of course material and assignments should be equally shared between the instructors.

Re-designing the course: Implementation

Phase -1: Discussion with senior colleague and restructuring the project.

Before the beginning of the course in block 4 of 2017, I had a detail discussion about the above listed issues and the possible solutions, with my senior colleague. He was quite supportive of my proposals. However, due to university policy on timeline (about two year in advance) of updating ILOs we decided to keep the same ILOs as 2016 while including additional information on the course home page for the students. We agreed on designing new ILOs for future. He also agreed upon including new material, but in a gradual form. We decided to include course material on solid state quantum information and computation for 2017 and kept for 2018, the required changes on the topics of decoherence.

He realized the importance of co-ownership in course material and assignments. But suggested that we should consider a gradual process in this regards. My understanding is that from his years of experience in teaching, he fears a complete derailment of the course, if this process is implemented suddenly. I appreciate his input in this regards and have started to gradually build my own material and exercises. One thing that we both found necessary was bring some new challenges nin the learning process for the students. For this we plan for example to introduce some open end problem sets for the course to be given in 2018. We also agreed on building a better synergy between us by having detail meetings for preparation of lectures and assignments. Since he knew that I am undertaking the KNUD course, we agreed that in a few of the lectures and assignment sessions I will test some of the pedagogical methods.

Unfortunately, we struck an impasse on the issue of assessment. My colleague even though understood my concern, however he is also of the feeling that oral exam is the optimal method of a assessment given the number of students and the time frame for exam. However, he did agree to create a standard questionnaire for the final exam that may be followed by us in the oral exam to judge the skill of students starting 2018. I am not fully satisfied with this solution and is still looking for a better method of assessment for this course.

Phase-2: Discussion with Pedagogical supervisors.

I discussed with the pedagogical supervisors about the changes that will be implemented in the course and the methods of teaching that will be used. I gave them the new course materials in terms of lecture notes, assignments and some articles that will be introduced in the course of 2017 for discussion. I also told them that I planned to use different pedagogical methods in adherence to the theory of didactical situation. In particular I considered standard lecture, peer review with group work and inductive teaching and learning. The supervisors showed lots of encouragement and gave vital inputs in pre-supervision meetings like, whether the newly introduced material are readable or not, how to make standard lectures more interactive, how much material should one consider in sense of time for inductive teaching and so.

Phase-3: Execution

As part of course re-designing, I implemented the following in the *NFYK13005U Quantum Information* course that I taught in *block 4 of the academic year 2016/2017*,

1. Prepared weekly summaries of what will be covered in the following week and published it in the course webpage along with reading material and exercises for students. In this way, we were able to better align the ILOs with the teaching activities (see Appendix B).
2. Included new reading material on solid state qubits for students to learn how these qubits are engineered and what can be done in quantum information.
3. Included new reading materials on how to make solid state quantum logic gates.
4. Included new reading materials on quantum algorithms.
5. Included two new lectures on solid state quantum information processing (see Appendix C).
6. Included new exercises on the physics of solid state qubits and on solid state quantum gates (see Appendix D).
7. Included two new research articles for discussion. The objective here was to make students understand the practical implementation of concepts of quantum information like creation of entanglement and making quantum logic gates using solid state qubits (see Appendix E).
8. Gave comments on several other exercises to co-instructor and helped him in improving their structure and explanation.
9. Implemented new methodologies for teaching like formative feedback, peer reviewing and inductive teaching (Black, Harrison, & Lee, 2003; Boud & Falchikov, 2006; Liu & Carless, 2006; Hounsell, 2008; Prince & Felder, 2006; McDermott, n.d.).
10. Created and used a questionnaire with some particular set of important questions for the final oral exam to help judge the skills of students.

Re-designing the course: Outcome

Aligning the ILOs with advanced summary of the coming week

The students appreciated this and felt that it helped them to prepare themselves for the material to be presented in the week. Also it gave them a clearer idea about what to expect from the course.

New course material and lectures

Students very much appreciated introduction of the new topic on solid state quantum information and computation. They however gave some crucial feedback that will help us to improve the course. For example they felt that the study material is too condensed and it is difficult for them to decipher it completely. I also realized it while teaching and could see a clear lack in preparation on their part. Some of them also find it difficult to connect the different inherent concepts on this topics due to lack of a more general introduction (see Appendix F).

As for the new material on quantum algorithms they were quite satisfied and enjoyed it. However, they did not like my inductive teaching and learning method for this topic. According to pedagogical supervisors, who were present in the session, the topic turned out to be too abstract to do in the inductive manner. They further said that, such topics need lot of experience of teaching to implement in the inductive method.

New exercises and execution

In general the students were satisfied with the problem set for the exercises, the corresponding discussions on it and also on the overall execution of it. However, they did said that the exercises where a bit hard, and also that they expect to see a more descriptive questionnaire for such exercises. They were critical about my approach to the discussions. Students felt that with the goal of making the session very interactive, I was actually pushing them to get involved in the discussions which was stressful to some (see Appendix F).

Research article discussion

Students liked this part of the course most. They were very satisfied even though they not necessarily understood all of the scientific article. In their feedback they mentioned that getting exposed to something like this was itself a fantastic learning experience. They also appreciated very much that very recent and relevant scientific articles were discussed. They also appreciated the guidelines, that we have prepared and given them with the articles, to help them understand them better (see Appendix F).

Assessment

The students were assessed and graded, on the skills they have built from the course, via a final oral exam of about 30 mins per student. Of the 30 mins the students gets 2 mins for preparation on the topic they will be examed. They have 15 mins of presentation and 10 mins on general question answers. For this exam I created a standard questionnaire to judge the potential and level of expertise of the students. The oral exam was taken over a period of two days to complete assessment of all students. During the first day of exam, observing the effectiveness of the standard questionnaire for student assessment, both my colleague and the sensor started using it to judge the skill of a student. I believe in this way we were able to create an unbiased assessment of all students. I believe as a result of this a high percent of students (bout 68%) of the 25 students who took the final exam got grades 7 and higher. We did agree after the exam, to further refine the questionnaire by discussing between us before next course year.

Conclusions

In general the project on partial re-designing of the course was successful. All the feedback and constructive criticism (see Appendix F) that we received from the students will be very helpful for further improvement of the course. As has been discussed above, there are still some issues and loopholes in the course that we need to address. Also, following student feedback I am in the process of writing some of the course material by myself as the existing ones in the literature are indeed quite condensed. Furthermore, there will be some restructuring of the exercises, lectures and my teaching styles following students feedback. Finally, there is still the question of finding a newer and better method of assessment. **The course was rated A by the Undervisningsudvalget (teaching committee) of Niels Bohr Institute, an improvement over the last rating of B that it got in 2016.**

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A Present ILOs continuing since 2016

NFYK13005U Quantum Information

Volume 2017/2018

Expand all

Education

Content

Learning Outcome

Skills

After the course the students should be able to explain how the various quantum information protocols work and why they are better than any classical protocol. Furthermore the students should be able to describe how to implement quantum information protocols in practice and discuss some of the problems, which arise when one tries to do so.

More specifically the students should be able to:

- describe how the BB84 quantum cryptography protocol works and how it is implemented in practice.
- define entanglement for pure states, and describe how to use it for super dense coding, cryptography, and teleportation.
- explain how entanglement may be generated experimentally for photons, ions and atoms.
- explain what a quantum computer is and describe how the Deutsch and Grover algorithms and quantum simulation work on a quantum computer.
- discuss general requirements for practical implementation of quantum computation and describe how these requirements are fulfilled for an ion trap.
- explain the teleportation protocol and how it may be implemented experimentally.
- explain Bell's inequalities and their violation in quantum mechanics
- discuss how decoherence and imperfections appear and influence experiments and know how to describe it in terms of the density matrix.
- relate the various parts of the course together and apply the knowledge gained in the course in new situations.

Knowledge

After the course students should know the elementary concept from quantum information theory including qubits, pure and mixed states, Bloch sphere, entanglement, super dense coding, teleportation, quantum repeaters, Bell's inequalities, entanglement purification, quantum error correction, and quantum computation algorithms (Deutsch, Grover, and quantum simulation). Furthermore they should know how one can implement quantum information processing in simple experimental systems such as photons and trapped ions.

Competences

The student will learn how the different logical structure of quantum mechanics, compared to classical mechanics, enables new possibilities for e.g. computation, measurements, and communication. Thereby the course will provide a deeper understanding of the quantum mechanics learned in previous courses. It will also provide the students with a background for further studies within quantum optics or quantum information, e.g. in a M.Sc. project

B Weekly bullentin to fix the ILOs on an ad hoc basis

Introduction to ion traps (https://absalon.instructure.com/courses/17101/files/934012/download?wrap=1) **(https://absalon.instructure.com/courses/17101/files/934012/download?wrap=1)** **(https://absalon.instructure.com/courses/17101/files/934012/download?wrap=1)**

"Quantum optical implementation of quantum information processing" by J.I. Cirac, L. Duan, and P. Zoller (http://arxiv.org/abs/quant-ph/0405030) p 6-8 and 12-17.

Movies illustrating the collective motion of ions can be found **here (https://www.osapublishing.org/oe/fulltext.cfm?uri=oe-3-2-89&id=63302#articleSupplMat)**.

Tuesday

Lecture:

In a previous lecture on solid state qubits we learned about superconducting qubits and how to implement single qubit rotations. In this lecture we will advance further and learn how to use superconducting qubits to make two qubit quantum logic operations. This is of great importance from quantum computation perspective as eventually a quantum computer build with such qubits will perform thousands of such logic operations. We will first learn how to couple two superconducting qubits. Then we will learn how such coupled qubits can be harnessed to build a CNOT gate.

This is currently a hot topic in research and as such it is hard to find some pedagogical material for reading. However we will soon upload some notes on how to couple two superconducting qubits which you may find useful to read. We will also after class upload the lecture notes. In the meanwhile you may want to look at this short **article (http://web.physics.ucsb.edu/~martinisgroup/papers/Martinis2012.pdf)** by John Martinis, one of the pioneers in this field.

Literature: **Coupling superconducting qubits (https://absalon.instructure.com/courses/17101/files/1326315/download?wrap=1)** **(https://absalon.instructure.com/courses/17101/files/1326315/download?wrap=1)** **(https://absalon.instructure.com/courses/17101/files/1326315/download?wrap=1)**

Exercises

In the second half of the class we will solve two exercises. The first is on how to **create entanglement in an ion trap (https://absalon.instructure.com/courses/17101/files/934041/download?wrap=1)** **(https://absalon.instructure.com/courses/17101/files/934041/download?wrap=1)** **(https://absalon.instructure.com/courses/17101/files/934041/download?wrap=1)**. The second is on **adiabatic elimination (https://absalon.instructure.com/courses/17101/files/934022/download?wrap=1)** **(https://absalon.instructure.com/courses/17101/files/934022/download?wrap=1)** **(https://absalon.instructure.com/courses/17101/files/934022/download?wrap=1)**. The last one is less important than the first and we may not have much time to discuss it. If we don't it is not a major problem.

Friday

C Sample of lecture notes on newly introduced course material

Electronics for Qubit Engineering

What we need :

Low dissipation

Nonlinearity

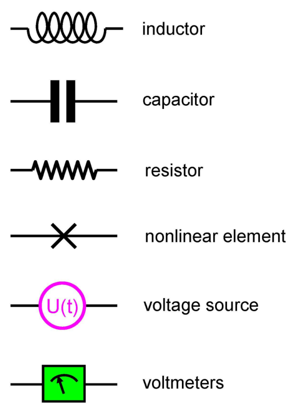
Low thermal noise

fulfilled by :

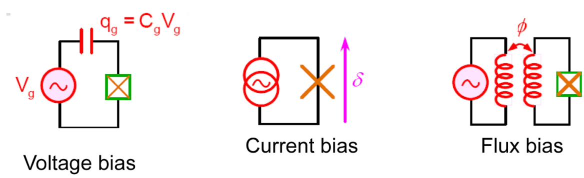
Superconductors

Josephson junctions

Low temperature



Hamiltonian of Superconducting circuits



Hamiltonian:

$$\mathcal{H} = \frac{(q-q_g)^2}{2C_{\sum}} - E_J \cos\theta$$ Voltage bias

$$\mathcal{H} - \frac{\phi\phi_0}{2\pi L}\theta$$ Current bias

$$\mathcal{H} + \frac{1}{2L}\left(\phi - \frac{\phi_0}{2\pi}\theta\right)$$ Flux bias

D Sample exercise

Solid State Qubits

Sumanta Das

(Dated: April 27, 2017)

Problem (2) in this exercise is actually a prelude to problem (1). However given that the course is on quantum information we put more stress on concepts/ideas or problems linked to it. Hence we decided to give problem (1) priority over problem (2). We though encourage you to try out problem (2) as it is quite interesting and cool from a fundamental point of view and by doing it you will learn a lot.

Problem 1: Hamiltonian of a superconducting charge qubit

(a) Starting from the Hamiltonian in the cooper pair number basis introduced in the class $\mathcal{H} = \sum_N 4E_c(N - N_g)^2|N\rangle\langle N| - \sum_N \frac{E_J}{2}\left(|N\rangle\langle N+1| + |N+1\rangle\langle N|\right)$, and using the discussion provided in the attached material (see last page) show that near the degeneracy point $(N_g \simeq 1/2)$ one gets the cooper pair box qubit Hamiltonian in the form

$$\mathcal{H} = E_z\left(X_{control}\sigma_z + \sigma_x\right) + \text{unimportant constants}. \tag{1}$$

Note that we have a factor of 4 in front of the charging energy E_c which is absent in the reading material. This factor arises from whether one considers the charging energy of a single electron or a cooper pair. You should not be worried about this and the physics of the problem does not change.

(b) What are the terms E_z and $X_{control}$? Express $X_{control}$ in terms of gate voltage V_g using $N_g = C_gV_g/2e$, where C_g is gate capacitance.

(c) What is the Hamiltonian in Eq. (1) at the degeneracy point $(N_g = 1/2)$?

(d) What are the eigenstates and eigen-energies of the Hamiltonian in (1) at the degeneracy point $(N_g = 1/2)$?

(e) Diagonalization of the Hamiltonian in Eq. (1) gives the energy level diagram shown in figure 1(a). Find the eigen-energies of the Hamiltonian (1) ? Can you see the nature of the energy levels from the eigen-energies you have calculated

E Sample questionnaire to discuss journal article

Manipulating the quantum state of a charge qubit

Sumanta Das

(Dated: May 1, 2017)

This exercise is not the usual type where we solve and discuss a set of problems related to concepts introduced in the lectures. Instead we want you to a read an experimental article where a solid state qubit, specifically a superconducting charge qubit was engineered and controlled manipulation of its state was achieved for the first time. The article we are going to study is: D. Vion, A. Aassime, A. Cottet, P. Joyez, H. Pothier, C. Urbina, D. Esteve and M. H. Devoret, Science **296** 886 (2002). We will discuss what goes on in the experiment and how they achieve control over the dynamics of the qubit state. Below we list a few questions, which can form the basis for discussion of the article. However this is not an exhaustive list and you are encouraged to also include some of your own thoughts during the discussion. To have a fruitful discussion on the article it is **essential that everybody at least read the article before the class** and preferentially also thinks about the list of questions provided below.

Note that while reading the article you will come across a discussion of the readout of the qubit. It is kind of difficult to understand and is not essential for understanding other cool things in the article. Hence you may skip over that part and need not be worried if you do not understand it.

(a). In the article it is said that for the Cooper pair box to be represented by the Hamiltonian $\hat{H} = E_{CP}(\hat{N} - \hat{N}_g)^2 - E_J \cos\hat{\theta}$ one needs the Coulomb energy E_{CP} and the temperature T to be smaller than the superconducting gap Δ. Do you understand why one needs to satisfy these conditions ?

(b). Can you detect the elements of the quantronium circuit in the scanning electron micrograph of Fig. 1(B). Note that, finding resemblance between the schematic circuit diagram in Fig. 1(A) and the scanning electron micrograph of Fig. 1(B) is not simple. Try to detect the Cooper pair box, the Josephson junctions, and the leads for external voltage control of the system.

F Student evaluation

What was good about the course? Why?

Very interesting subject overall.

Very interesting topic! Interplay between abstract theory and (even though typically rather involved...) current research papers was very rewarding - its nice to see people outside the course cares about the things discussed.

Exercises were difficult, but help from Sumanta and Anders helped a lot. Office hours is an amazing offer, even though I only used it sparingly, I benefited a lot from them.

The application of quantum mechanics really is a good practice for all physicists to strengthen their understanding. So this course really took me off guard, since it was a bit more theoretical than assumed, but it was a nice surprise!

I think that working with relevant scientific papers has been interesting and I have gained much knowledge from the discussion segments. I thought the articles were accessible and a good level of difficulty with our background knowledge from the course.

I generally think the reading material was well chosen and helpful.

The exercises were great! They were fun to do, felt very relevant and almost every exercise had some surprising result.

Very good lecturers and interesting topics.

The Qdev article was too technical to read (I almost died of boredom) but the following discussion was very useful and it was cool that Casparis was brought in.

I thought the Superconducting Qubit review was horrific to read - a big mess - and I had to spend a lot of time on my own and in discussions with friends to figure out what was going on in this topic.

In a few of the exercises, it was difficult to understand what exactly one was supposed to do.

Generally there was never enough time to complete the exercises in class. If this is on purpose, it would be good to let the students know that they are supposed to start work on the exercises before class.

Sometimes the use of certain didactic tools seemed a bit forced (like the "discuss with your neighbours" things), but I guess that is the sort of stuff that comes with experience as a lecturer.

16

Congruence in teaching

Enhancing congruity on the masters course Sensory Biology

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Introduction

The dramatic expansion of student enrolments in higher education that has typified the 21st century has demanded a dramatic shift in teaching practices from elite to mass forms of education. This shift towards 'mass higher education' has required a transformation of the conceptual framework surrounding a given course setting – or teaching-learning environment (TLE) – to include not just the organization and provision of teaching, but a much broader set of dimensions. In accordance, Biggs (1996) introduced the concept of 'constructive alignment' in which intended learning outcomes (ILO) must be aligned with appropriate teaching activities and assessment tasks for a given course setting to work optimally. Building on this model, a study by D. Hounsell and Hounsell (2007) introduced the concept of 'congruence', which sought to capture an even wider array of direct and indirect, intentional and unintended contextual influences that may affect the TLE (Fig. 16.1). It has thus emerged, that multiple levels of congruence need to be considered when seeking to design and achieve high-quality learning outcomes if we are to meet the contemporary needs of mass higher education.

In this work, I will critically analyze and discuss elements that may improve congruence within the TLE of the masters course Sensory Biology, with the aim of highlighting actionable initiatives that could enhance the student-learning experience. Specifically, the analysis will be focused on selected dimensions of congruence, i.e. the constructive alignment of as-

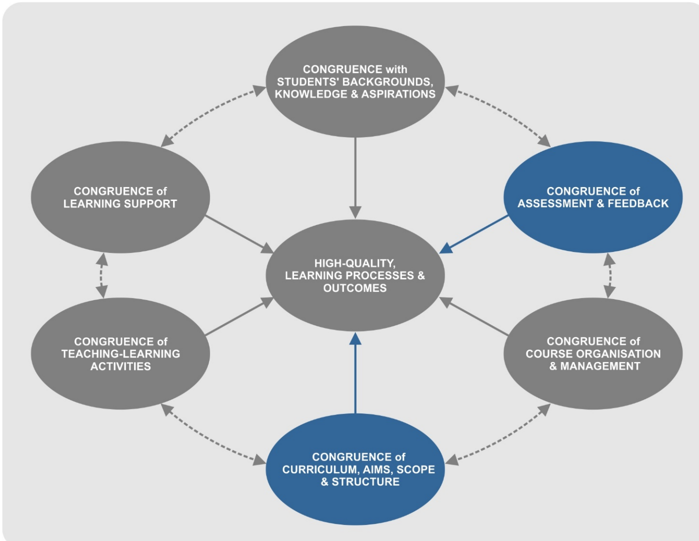

Fig. 16.1: Various forms of congruence within TLE. Levels of congruence identified for analysis and discussion in this work are highlighted in blue. Modified from: D. Hounsell and Hounsell (2007).

sessment and feedback on the course (Biggs, 1996) (see Fig. 16.1), and will primarily be based on both formal and informal student evaluations, in addition to my own personal observations. The formal student feedback originates from the electronic course evaluation conducted automatically at the University of Copenhagen, while oral feedback given in private and/or in plenum (both during and at the end of the course) has been documented in notes. Quotes from both sources will be highlighted and discussed throughout this work.

Overview of the course Sensory Biology

The course Sensory Biology is part of the MSc program in Biology at University of Copenhagen. The course deals with animal senses – addressing all levels of biological organization, ranging from receptor molecules to animal behavior for a broad range of sensory modalities – and aims to provide the student with a broad, comparative overview to the field. The course further aims to provide basic insights into experimental design with a focus on providing hands-on experience with some of the basic techniques in experimental neurobiology. The course typically attracts 20-25 students, of which 5-8 students come from various nationalities (with inherently different study cultures), and consists of lectures, tutorials, colloquia and practical exercises. Each of the four different practical exercises is concluded with a written report, the approval of which is a prerequisite of attending the exam. So is general and active participation, including presentation and discussion of original literature with the other students, required for completion of the course. Moreover, the students generally have very different academic backgrounds, which creates significant challenges for the design and provision of teaching. The course is taught entirely in English, the student workload is 7.5 ECTS, and the course is assessed by an oral examination (without preparation time) counting 100% of the final grade.

I am one in five different lecturers on the course, and I give both lectures and teach 2 out of four practical exercises (including correction of reports) in addition to censoring/examining during the final assessment. Moreover, there multiple guest lecturers presenting state-of-the-art within selected themes. As such, the course has a complex structure consisting of many different modes of teaching, taught by many different lecturers with implicit challenges in creating a coherent TLE.

Congruence between ILOs, TLAs, assessment tasks and feedback - which aspects of current practice may be improved?

In order to identify aspects of the current teaching practices that may be improved for next year, I analyzed the formal and informal student evaluations, in addition to my own personal observations and notes from this year's course (Fig. 16.2). This analysis highlighted specific elements that should be prioritized for improvement for coming year's course, which I will discussed below:

Do the student see the assessment as adequately addressing ILOs?

The ILOs for the course is highlighted in Box 1. The ILOs have a SOLO level of 2-4 according to the SOLO taxonomy (Biggs & Collis, 1982;

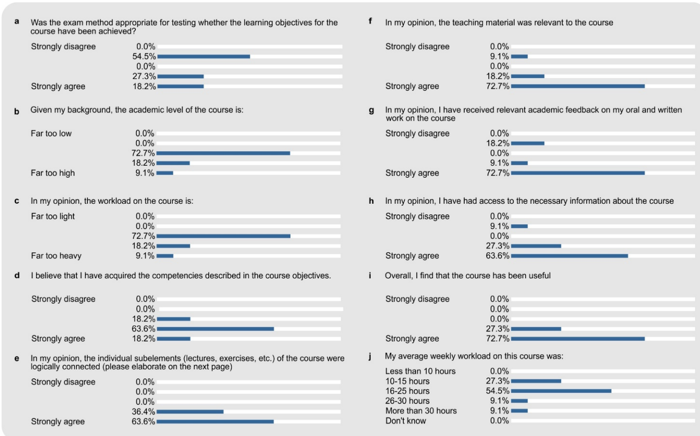

Fig. 16.2: Student evaluations of the course Sensory Biology. A total of 23 could answer the evaluation schema, 11 answered the evaluation schema, resulting in an answer percentage of 48%.

Brabrand & Dahl, 2009), and they are largely made operational via tutorials, colloquia and practical exercises. The students are generally satisfied with the course (Fig. 16.2). However, when considering the selected assessment task (oral examination without preparation time counting 100% of the grade), it is questionable whether the selected method is optimally aligned with the ILOs. Is an 'on-the-spot' oral examination a fair representation of the student' performance during the course? Is this assessment task a reflection of what we want the students to learn? According to the student evaluations, the answer is no! More than 50% of the students who answered the course evaluation replied that this was an inadequate method to assess if they had achieved the ILOs of the course or not (Fig. 16.2a). Indeed, the experimental design aspect (ILO nr. 4) of the course is not assessed using this method. One student made this comment to me after the course *"I really liked the course, but I felt the exam was a little unfair. You only got to talk about a very small part of the curriculum, and because you are so stressed during the exam, you easily forget what you know"*. As stated above, the course requires a significant active participation in teaching – most notably the four different experimental practicals and associated reports – to be able to pass the course, yet none of these activities are evaluated in the award of the final grade. Consequently, a student who has performed 'outstanding' throughout the course could in principle still receive a low grade if the student performs badly at the oral exam. Conversely, a student who has lacked commitment throughout the course could still end up with a good grade if they are examined in the one chapter they have cared to read. It is well documented that the choice of assessment task greatly influences what and how students learn; essentially, students learn what they think they will be tested on i.e. the backwash effect (Elton, 1987). As such, a misalignment between the ILOs and the choice of assessment task may unintentionally encourage a surface approach to learning, resulting in the students never meeting the ILOs of the course. Clearly, the current assessment task could be better aligned with the ILOs if the course. Specifically, converting the assessment to a so-called portfolio exam, in which the student's performance during the different TLAs are included in the final grade, represents an attractive alternative. Practical exercises and reports: 40%; dissemination and discussion of original literature: 20%; oral examination: 40%. This would achieve a much better alignment between ILOs, TLAs and the assessment tasks on the course, and would help guide the students towards deep learning approaches throughout the various course activities.

Do the students receive relevant and sufficient feedback on their work?

Although most of the students agreed that they had received relevant academic feedback on their written and oral presentations (Fig. 16.2g), several students mentioned in their course evaluation that they had not received sufficient feedback on their reports. One student simply stated *"Better feedback on the reports"*, while another student wrote, *"It was unclear whether the reports were automatically approved when we handed them in or if we were expected to correct them and resubmit"*. In line with this critique, and to work towards converting the assessment task into a portfolio exam, the reports on the practical exercises could be changed into a feed-forward assignment with the format "draft - comment - revise - resubmit". Although this would invariably take up more time spent on this TLA for the teachers, it would also promote the students to become much more engaged in the report writing. Indeed, this approach would take advantage of 'student backwash' to help achieve the ILOs of the course, because when the students know they have to respond to the formative feedback given, and that the report ultimately counts towards their final assessment, they will approach the task in a very different way! However, as previously stated, implementing this change could potentially become very time consuming for the teachers on the course, and so it would become very important to evaluate on the benefits of this approach. Would this actually improve on student learning measurably, or could our time be spent better?

Box 1. Intended learning outcomes (ILOs) for the Sensory Biology course.

1. Interpret the connection between animal behavior/communication and the underlying sensory biology
2. Determine the modality of a sensory organ based on its structure
3. Evaluate and compare the quality of the sensory input across sensory modalities and animal groups
4. Design and set up experiments (including electrophysiology) on the quality and functionality of the sensory input from a range of sensory organs

Summary and conclusions

Analysis of student feedback and personal observations of selected elements of congruence within the course has revealed some points relating to the assessment tasks and feedback that may be better aligned with the ILOs in the future. In particular, student evaluations suggest that changing the current assessment task from an oral examination into e.g. a portfolio exam, which better assesses all the ILOs of the course, would ensure much better alignment between the ILOs, TLAs and the assessment on the course. Furthermore, changing the report writing on practical exercises into feed-forward assignments, in which the students get to work with the feedback provided, would help promote deep learning approaches, as well as support a transformation of the current assessment task. In general, this type of analysis underlines the importance of performing a continuous evaluation and revision of a given course setting in order to ensure optimal provision of teaching and student learning, which supports mass higher education.

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17

Who needs Popper in public health?

The challenges of teaching ’theory of science’ to public health students

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Background

In the fall of 2015, I became course responsible for the course *Ethics and Theory of Science* (’Etik og videnskabsteori’) within the Bachelor program in Public Health. I had previously been affiliated with the course by being one of the teachers for the ethics section of the course. The course is mandatory for obtaining a BA in Public Health and counts for 5 ECTS points. The course runs every fall semester in the first year of the Bachelor degree. The course is divided into two sections (ethics and theory of science). Students have six lectures in each of the disciplines. Duration of each lecture is 45 minutes. After the lecture, students meet for a two hour SAUs which are group sessions where they work more practically with the theoretical lessons from the lecture, for example by analyzing cases and developing their conceptual understanding. I teach the classes in ethics. I do not teach any SAU classes or the lectures in theory of science. The exam form changed in 2016. It used to be an oral exam with an external assessor. It is now a written exam (2 questions, 48 hour, 4 pages paper, pass/fail). As course responsible, I assess all papers. There is no internal or external assessor.

When I took over the course, I redesigned the entire ethics part. Previously the course was leaning towards medical ethics. Considering the fact that this is a course for Public Heath students and not medical students, I felt compelled to change the literature and the content of the lectures in ethics so to align the teaching with the field of the students (Biggs, 2002).

The ethics part became specifically about public ethics. As indicated in the course goal description ('Fagets målbeskrivelse'; see appendix A) students need to be familiar with theories and principles/concepts within ethics and theory of science. I decided, at least in the ethics section, that they should not read primary literature (for example, Kant) as these texts are too complex and difficult for their level. I found a book on public health ethics (Holland, 2015) that they read relevant chapters from. This book serves as a textbook and is thus the primary source of information in relation to ethical issues within public health.

Since the beginning of my tenure as course responsible, I have been occupied with the aim, content and structure of the theory of science section, in particular, and how to best tie it to the ethics part. My background is not in the field of theory of science and thus I have struggled to find the red thread in the six lectures and appropriate literature where each lecture leads to the next and tire naturally to issues in public health. This sentiment is echoed by students in previous evaluations of the course. They are often bewildered when going through the classes and have a hard time finding the relevance to public health: Who needs Popper when you study Public Heath? Though they may see the relevance later on in their studies (or so older students report), it is important that they sense the relevance even if they cannot verbalize yet while taking the course. It is important for their engagement in the class and for their learning process. Nobody benefits from students mentally tuning out in lectures and who are passive in group work.

As a teacher, it is frustrating situation to find oneself in and it has led me in this paper to examine the didactic and educational challenges of teaching theory of science to undergraduate public health students. In light of these challenges, the paper wishes to suggest how to design an effective learning environment that will augment the learning experience for the students. I am interested in becoming informed about what theory of science means to public health students/teachers within the context of public health, why theory of science seems difficult and often perceived irrelvant to public health students and, finally, what the didactic and educational challenges are in terms of teaching/form and in terms of curriculum/content.

Method

In order to support my own interpretation of the frustrating situation of designing a course that has numerous educational challenges in terms of form and content, I decided to conduct a interviews with a couple of teachers who have longstanding experience teaching the course in various departments at the Faculty of Medicine. Since the student perspective is important to understand in order to accommodate their needs, I posted a notice on Absalon where I described the purpose of my paper and asked the students to answer some questions. In the hope that the participants could cast further light on the issue from different angles (teacher and student), I posed four questions to all participants:

1. What do you find difficult/problematic/challenging about 'theory of science' as it now looks in Public Health?
2. How would you like to have the material presented to you in class (for students)/how would like to present the material in class (for teachers)?
3. Do the two sections, 'ethics' and 'theory of science', complement each other? If yes, how?
4. What do you think of the teaching style (lectures and SAU)?

This paper will first convey the lessons from the teacher and student interviews and, subsequently, introduce a series of suggestions as to effectively create a better learning enviroment. The suggestions are born out of my own reflections over the years about the didactic and educational challenges of the course, particularly with 'theory of science' and the outcome of the interviews.

The Interveiws

My micro-empirical study started with the two teachers. After interviewing them, a broad pattern emerged that was somewhat surprising. The two teachers have both taught this course or similar courses for many years and thus draw on immense experience. Both teachers are convinced that theory of science has an important place in Public Health primarily as a critical thinking tool for the students. However, they express that the biggest challenge is to get the students "to lean back, give time and believe that they will eventually get some overview and understanding of the subject matter" in the words of one of the teachers (question 1). In answering the second question, one teacher could not see how abstract material could be presented differently from now without running the risk of making it too superficial. He also pointed to the need for a double lecture instead of the single lecture at the moment. This is a sentiment that resonates with the students as they have aired the same wish in the past. As a consequence of the abstract character of theory of science, the other teacher has played with different ways of presenting the material, mentioning his use of illustrations and short YouTube clips to exemplify the content matter, for example sensory perception and interpretation. The two teachers diverge somewhat in question number 3 as one teacher believed that the two subjects (ethics and theory of science) do complement each other though it is difficult to show how they converge, whereas the other didn't, stating that "they touch on different areas of reality: the theory of science is a scientific-technological descriptive, causal-related thinking; but ethics is about normative theories where the subject field is interpersonal relationships, or relationships between human beings". Both teachers find the combination of lectures and SAU excellent as the latter "offers the students the possibility of getting the concepts and theories explained further and processed through discussions and assignments, i.e. a better practicalization of the lecture content". This teaching format opens up students to the material through their own questions and, thus, makes it more possible for them to explicitly understand it.

I had anticipated more responses from the notice I posted on Absalon encouraging students to answer my questions. I only received 2 written responses. I am therefore glad that I incorporated some of the questions into the obligatory dialogue-based evaluation that I carried out at the end of the semester. At least 80% of students attended this final class that also prepared them for the exam. The students were by and large active in verbalizing their opinions of the course. Combined with my two written responses, I could draw a general picture of their perception of 'theory of science'.

The biggest surprise in the data material was to see how aligned the students' responses were with that of the teachers'. Using other words, the students mimiced the board picture portrayed by the teachers. In pointing to the highly abstract subject of theory of science, they called for the need for double lectures and more examples to illustrate the content and relevance of theory of science to public health. They drew attention to the beneficial combination of lectures and SAU where they were given a chance to work more actively with the material. They pointed to the educational use of case studies and encouraged teachers to incorporate more examples in the lectures so to get a clearer understanding of how theory of science applies to the field of public health. In the dialogue based course evaluation many students expressed that they found the two subjects very different explaining how they could easily relate ethics to publich health but not theory of science. They underlined how valuable the group work was both as a test to their understanding and because of the discussions it generated. They mentioned how helpful it had been, during my introduction to the course at the very beginning of the semester, to hear that they did not need to bridge the two subjects, 'ethics' and 'theory of science', but could regard them separately since they were cut into two sections with six lectures in each. One student pointed out in the written response that though she had a vague notion of how the two subjects are tied together, "it was good to have them divided up with theory of science first, followed by ethics – otherwise it would create confusion".

Though the responses confirm the remarks and evaluations over the years in regards to the difficulty of theory of science, they clearly indicate much less of a problem than I had anticipated. This insight is valuable to me when designing an effective learning environment because it helps me callibrate the meassures I need to take to address the challenge of the course more realistically. In other words, I may not need to resort to drastic meassures (major changes) but small, creative ones. Some of these changes or additions are not directly linked to the content matter of theory of science but the way it is being presented to the students. These changes, however, can carry significant didactic and educational weight that will make theory of science more accessible to students.

Designing an effective learning enviroment

"Effective university teaching is a holistic endeavour that embraces not only the practice of teaching but an understanding of how students learn" (Hunt, Chalmers, & Macdonald, 2012). How can I use didactic and educational tools to improve my students' learning? First, let me introduce who my students are. My students are undergraduate students who predominently are straight out of high school, i.e. between 18-21 years of age. The vast majority of them are young women with a very high average DPA (average grade) who are copiously determinate, motiviated, driven and ambitious. They are used to setting goals and working hard. Encountering 'theory of science' is a shock to most of them. The thinking involved and the language are different from what they are used to. The subjects seem abstract and far removed from what they think they need for their public health studies. As the students view this course as a very abstract (and demanding) course according to evaluations, I have thought of ways to guide them through the literature they read. In their evaluations, students have requested hand-outs that indicate what to pay special attention to in their readings. I may make a list with key concepts to focus on for each class. It seems to be in line with what they have been used to in high school. Since this course is their first at the university, handing out this conceptual guide may ease the difficult transition from high school to university. Last year I handed out a list of concepts for the ethics part and for the theory of science part. They seemed to be grateful for having this as a guiding tool as they got a better graph of what were the most important concepts to understand. The students from this year mentioned the value of having these concepts in preparing for the classes. However, I was also afraid that they would simply skip to where these concepts appear in the text and miss the context and how these concepts connect to other less important points in the literature. It will be difficult for me to find out in the lectures as discussions are limited but I have informed my SAU-teachers to watch out for this particular problem.

Though I am not sure if I can enforce the students to keep a learning log, I find several advances in keeping one. This log could be an integral part of SAU work. A learning log is where I/we set aside some time (usually a few minutes) at the end of a class for students to write about what they have learnt today. In that way they have a log book at the end of the semester that can help them with preparing for the exam. I would, of course, have to also note down what I find is the most important 'take home' lessons of the particular classes, so for the students to compare their one with mine. This seems important as I would not see their learning log and therefore not be able to correct mistakes. On a trial basis, my SAU-teachers and I came up with the idea of a 5 minute writing exercise at the beginning of the SAU to practice writing since their exam in now a written exam. Eventually, we could develop the log book idea into SAU.

I have not priviously considered the use of electronic devises to advance the learning process of students. Being new to the possibilities awarded by technology, I think I should explore some of the online platforms to be used in the classroom. I could experiment with, for example, word clouds in my classes. Seeing the word cloud on the screen would visualize learning points for the students and give me a chance to specify key concepts that they need to know. Web-clickers could also be used as means to 'peer instruction'. I found out that there are several web-clickers on the market. The student response system that professor Jan Halborg Jensen has used on his blog with great success is called 'Socrative' but there is also 'menti.com' (word cloud based on the responses from students) and 'Shake-speak' which can be added on to a power point presentation which would be useful and practical. The advantages of web-clickers is that it can improve the attention span by inserting these reflective 'pauses' where the students have to take a stand, add a dose of fun to the lecture format and make the subject more accessible and visible. On the other hand, the down side could be that it serves as a distraction, reduces the complexity of the subject to one-liners and prevents stimulating the student to work harder with challenging topics.

Another way that Halborg Jensen inspired me was in his decision to video tape his lectures for the students to view at home in advance of them coming to class to discuss the lecture and before going to attend their 'SAU'. Though setting this up would be time-consuming and essentially not a decision for me to make as I would need the Department's and the Study Board's approval, it is worth looking at. The advantage is that this format would encourage the students to work actively with the material and give them a greater chance of exchanging thoughts and posing questions in the classroom. A learning by doing approach. The downside is that if students do not watch the video, the idea falls flat on the ground in the class room because they have nothing much to contribute with in the classroom.

The splitting up of the course into two sections helps the students in one way, but it may also benefit them to consider mixing the two. This suggestion would require, however, a completely new structure of the course. A new structure where the two subjects are interwoven would underline the interconnectedness of them within the framework of public health and adopt a more pragmatic approach to the course instead of a theoretical approach as it is at the moment. One pragmatic approach could be to take a concrete problem and analyze it through theory of science and ethics. An example of this approach could be 'personal medicine' where the ethical issue could be 'informed consent' and the issue within theory of science could be the question of how much we know and how we scientifically determine what we know.

Finally, I think that improving note taking is important and can be done by, for example: Framing questions (what are the major questions in the topic for today), handouts (of major points and things to focus on) and summaries (recaps through out the lecture).

Conclusion

The course has suffered from problems of relevance and level of abstract thinking over the years, some of which have been resolved by changing the ethics curriculum (change of literature), focus (public health ethics) and teaching style (incorporation of examples and case analysis in teaching). However, students still wonder why and how Popper and co. is relevant for their future work in public health.

By incorporating some or all of my suggestions for effective learning, I hope to make students reflect more on their own learning and more clearly acknowledge the relevance of theory of science to their field of study while taking the course and not, as now, realizing it a couple of years later. Small changes that foster a creative attitude to learning will make an abstract subject less inpenetrable and more enjoyable to engage in.

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A

Fagets målbeskrivelse

Efter endt kursus forventes den studerende at kunne:

Viden

- Beskrive overordnede teoretiske retninger indenfor videnskabsteori og etik
- Refleksiv forståelse af centrale principper og begreber inden for videnskabsteori og etik
- Beherske videnskabsteoretiske metoder, der indgår i pensum, herunder årsag og virkning, hermeneutisk fortolkning, og hvordan man kan teste hypoteser.
- Reflektere over etiske aspekter i folkesundhedsvidenskabeligt arbejde

Færdigheder

- Anvende videnskabsteoretisk tænkning og etisk ræsonnering i relation til en konkret problemstilling i folkesundhedsvidenskab
- Vurdere kritisk etiske og videnskabsteoretiske problemstillinger inden for folkesundhedsvidenskab
- Læse og bedømme etiske og videnskabsteoretiske oplysninger i rapporter, videnskabelige artikler og medier
- Gennemføre etisk analyse af folkesundhedspraksisser og udforme klar videnskabsteoretisk kausalitetsvurdering og metodeanalyse

Kompetencer

- Overføre kendskab til forskellige videnskabsteoretiske og etiske positioner og dertil hørende teorier til anvendelse inden for folkesundhedsvidenskab
- Præsentere selvstændige indsigter i videnskabsteoriske og etiske positioner i relation til folkesundhedsvidenskab
- Indgå i sundhedsfagligt projektarbejde hvor videnskabsteoretiske og/eller etiske oplysninger og metodik har betydning enten som produkt af eller som beslutningsgrundlag for det overordnede projekt